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Fundamental and Applied Research

Not very long ago the average man knew no better definition of "applied" and "fundamental" research than "useful" and "useless". To the planter, concerned with his practical problems, fundamental research seemed to be something remote and mysterious, unlikely to be productive of results that would help him. As evidence of the disfavour into which the term "fundamental" had fallen, the Imperial Agricultural Research Conference of 1927 defined the duties of a Central Research Station by the almost equivalent terms of "wide range" and "long range" research. And since then those concerned with research have been chary of using the word "fundamental". Recently, however, interest in fundamental research has grown in East Africa, and at least one important planters' organization has discussed how it may be encouraged and augmented. The time seems appropriate for a discussion of what we mean by fundamental research and the respective parts that fundamental and applied research can play in agricultural development.

It is by no means easy to grasp the distinction between fundamental and applied research, or, for one who grasps it, to explain the distinction. To say that fundamental research aims at discovering those foundations of knowledge upon which applied research should be built does little to remove the difficulty. Practically it is convenient to say that fundamental research is essentially the kind of work done by a Central Research Station like Amani; applied essentially the work

of an Agricultural Department. The distinction between the two branches is anyway far from clear cut; and this convenient method of division is not always true, for some Departments do considerable amounts of fundamental research.

We may perhaps obtain a clearer idea of how the two branches work by considering an example recently familiar to most who are concerned with coffee. This is the problem of shade. Applied research approached this problem with no knowledge on which to form an hypothesis for the ideal shade for coffee; under these circumstances it could do no more than lay down an experiment comparing different kinds and different intensities of shade. Now an experiment like this can provide only one piece of information: that in such-and-such a locality the best results are given by such-and-such a form of shading. Since the experiment gives no evidence concerning the manner in which shading has influenced the functioning of the coffee bush, it is impossible to say whether the results obtained in the one locality will apply in another. The only course is to carry out another experiment there. And so experiments multiply, results are discordant, and we are still left with no theory of shade that can form a satisfactory basis for an advisory service. This hypothetical account is not far from a true statement of what has in fact occurred in East Africa.

Now notice what is the fundamental worker's approach to this problem. He studies the physiology of the plant under different conditions. At this stage in his research the effect of shade is only incidental to the study of the way in which the plant works. As is now well known, these studies revealed that in Arabica coffee the stomata closed and carbon assimilation ceased when the leaf was exposed to full sunlight. Under a cloudy sky or any form of shade the stomata remained open and carbon assimilation proceeded. We may reasonably assume that conditions favouring this process, since it provides the plant with its carbohydrate reserves, also favour the general well-being and productiveness of the plant.

Here then is a theoretical basis upon which a policy for shade can be formed. But note that it is not the final solution of the planters' problem. It provides a working hypothesis for the applied worker; but its application to practice must await the results of experimental trials by the applied worker. But it is evident that, equipped with a guiding principle, the applied worker can design his experiments with much more economy than previously and can expect to get conclusive results much earlier. By studying the climate of each locality and the occurrence of clouds, he can make a fair guess at the coffee's requirements for shade; but he must still carry out his trials. Only when these trials have shown that there is no unsuspected fallacy can he safely advise the planter.

We should note, however, that in all possibility fundamental research has not finished the contributions that it can make to this problem. The applied trials may well reveal unsuspected fallacies; shade may be found to influence other functions of the plant, so that what is ideal for maximum carbohydrate production may prove to have compensating disadvantages. Then once more it may be necessary for fundamental research to study another aspect of the plant's functioning.

From a consideration of the foregoing we may appreciate certain important principles. The first is that economy is generally obtained if fundamental research precedes applied. Once fundamental research has supplied a working hypothesis, the task of the applied worker is greatly shortened. In agricultural re-

search, applied work has tended to precede fundamental; and undoubtedly it has solved successfully many problems. Some problems it has failed to solve, and, unassisted by fundamental research, is unlikely ever to solve. Ideally the applied agricultural research worker should start only when fundamental research has completed its task; in practice, fundamental research tends to come in at a late stage only when applied research has perceived that some of its problems are insoluble by its methods. But fundamental research would have simplified the whole task of the applied worker.

Note also that, once fundamental research has shown how the plant functions, the applied worker is equipped not only to solve the problem of shade, but probably many other problems in the cultural treatment of coffee. The results of fundamental research hold for all times and all places.

A third important point is that within an ideal research service fundamental and applied research are complementary and interrelated one with the other. If the applied worker is often entirely dependent on the fundamental worker, and always greatly helped by him, the community is entirely dependent on the applied worker for translating into practical form the findings of fundamental research. The applied worker is the essential link between all research and practice; he occupies a key position and is the most important unit in any research service.

We cannot too strongly state the importance of the part played by the applied research worker. A tendency is evident to regard the fundamental worker as a superior being, and for the applied worker to feel that his status is inferior. There was never a greater fallacy. The qualifications required of each are different; if the fundamental worker needs the greater academic qualifications and profounder scientific knowledge, the applied worker must possess the balanced judgment, experience and human understanding that make him both a scientific and a practical man. Both workers have honourable tasks to perform for human welfare; if their relative importance to the community must be weighed, the balance must go to the applied worker.

There is the greatest need for mutual trust and understanding between the two branches. Fundamental research provides the raw material of applied research; without fabrication by the applied worker that raw material will be of little use to the community. The fundamental worker's task is service to the applied worker. His work should rarely come directly to the notice of the farmer, but only as interpreted into practice by the applied worker. A minor point, but important in its influence on that mutual understanding and trust that we desire, thus emerges: that the fundamental worker must rely almost entirely on his interpreter, the applied worker, for any public appreciation that his work may gain.

These considerations help us to perceive the great task that lies before the proposed inter-territorial committee for coffee research. That committee is intended to co-ordinate the work of all branches of research on coffee in all the East African territories. It is to prevent unnecessary work of duplication in different places and to ensure that results obtained in one place are known and used in others. It is to interpret the findings of fundamental research to applied workers and to see that they are developed and moulded into practice. Perhaps its greatest task is to foster and maintain a spirit of co-operation and appreciation between fundamental and applied research workers.

This proposal places the organization of research in the hands of a committee of research workers. There are evident advantages in controlling so specialized an activity as research by a body that consists of persons who have themselves done research. At the same time the proposals of this committee must be approved not only by the relative authorities of Governments but also by the constituted bodies of planters' representatives.

Planters naturally, and rightly, desire to maintain some control over research that is done on their behalf. No one is better qualified to know the problems of the industry or to define the ultimate aims of research. Much will depend, however, on the forbearance with which they exert their control. To designate the port of arrival is the function of the planter, but navigation of the ship of research, and the choice of the course it should take, should be left to the research worker.

Control of research, whoever exerts it, requires a special interpretation. Research is a thing of two parts: one, the collection of data, and the other, the interpretation of the data by thought. Into the latter enters that intangible quality of the good research worker, inspiration or genius, without which research is sterile and lifeless. In the building of a research service the first need is a staff mentally equipped to perform the second function; and the second need is to provide conditions that encourage him to use this mental equipment. Business management gives the converse of the required conditions; too much organization drives out genius and leaves no time for thought. Control of research really means the study and understanding of the individual research worker, his encouragement and guidance into those lines of research that he is likely to make productive, and the appreciation of the results that he obtains. We must ever be on our guard against converting a research service into a mere organization for the collection of data.

H. H. S.

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Plant Hormones

The researches of a plant physiologist upon the bending of young oat seedlings towards the light would not seem to promise much benefit to agriculture. Yet from such beginnings has grown the knowledge of plant hormones that is already finding application in the vegetative propagation of coffee.

For a number of years it has been known that in man there exist certain substances capable of exerting an important effect on the life of the body. These substances, the hormones, are internal secretions of glands; although occurring in minute quantities, they stimulate or "oil" certain complicated reactions on the body. A well-known example is insulin, which is naturally produced by the pancreas. If the pancreas fails to produce insulin, diabetes develops.

More recently physiologists have demonstrated that similar hormones are produced by plants. They have been shown to exert their main effect in controlling growth and the development of the root-system. First, the work of Fitting, Boysen Jensen and others showed that certain phenomena of growth could be explained only if growth-controlling substances were assumed to be produced in the plant. Although the quantity of these substances in a plant is extremely minute, in the early twenties Went successfully extracted a crude hormone, and later he and others separated it into three substances, called Auxin a, Auxin b, and Heteroauxin. These materials were shown each to be capable of increasing the growth of the shoot and roots of a plant

to which they were applied. In their absence a plant, deprived of the power of manufacturing its own hormone, failed to grow.

Obviously here was an advance that might be of value to the horticulturist. The difficulty of obtaining sufficient quantities of hormone at first prevented practical use; but a productive source of plant hormones was discovered, strangely enough, in human urine. The real advance came when the biochemists Kogl, Hoogen Smit and Erxleben demonstrated that the hormones were known chemical substances and could be synthesized in the laboratory.

The resulting large supply of hormones led to much work on their employment for root cuttings of plants that had previously proved difficult. So successful have been the results that a commercial preparation of hormones has recently been placed on the market.

In our last number we published an account of certain preliminary trials in Kenya of the commercial "Hortomone A" and a pure hormone in improving the rooting of coffee cuttings. A great improvement in the rooting was recorded. It should be noted that these experiments were carried out under carefully controlled conditions, and haphazard use of the materials might well fail to give comparable results. Certain points must receive particular attention. The state of dilution of the hormone administered is of paramount importance, and instructions must be exactly followed. Too high a concentration will do more harm than good, as Gillett and Jackson found, since indole acetic acid at 4 parts in 10,000—ten times the maximum concentration ordinarily recommended—produced a retarding or semi-lethal effect. Another point is that the materials rapidly decompose when diluted; the solutions should be freshly prepared for use, and exposure to strong light should be avoided.

J. G.

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Erosion

To see the extent of our own problems clearly is not always easy; hence the importance of visits such as that paid to East Africa some months ago by the Agricultural Adviser to the Secretary of State for the Colonies. Sir Frank Stockdale's visit was necessarily curtailed to two months; nevertheless, he was able in that time, as the result of constant travelling, to see our agricultural problems as a whole better than any local observer could hope to do. This visit was followed recently by two valuable contributions [1] [2], one dealing wholly, and the other partly, with the subject of soil erosion, in both of which a grave warning is sounded on a process that has been going on in East Africa for many years, sometimes almost unnoticed. As Sir Frank, apart from previous service, has visited and reported on practically the whole of the Colonial Empire within the past ten years his experience is unparalleled. For this reason it is disturbing to learn from him that the most serious soil losses in the whole of the Empire are taking place in East Africa, particularly in Kenya, while an ironical feature of the situation is that similar losses might also be going on in Tanganyika Territory and elsewhere to a large extent but for our old enemy the Tsetse fly which has driven off man and beast and so preserved vegetation and consequently the soil.

[1] Soil Erosion in the Colonial Empire. Emp. Jour. Expt. Agr., Vol. V., No. 20, pp. 281-297.

[2] Report on Visit to East Africa, January-March, 1937; C.A.C. 345, Colonial Office, London.

The survey of the problem to be tackled is impressive, but the means suggested, or already being taken, to combat the trouble are no less so, and if energetic steps are taken without unnecessary delay the position may be saved within the next ten years.

The problem as portrayed is a peculiarly wide one in that physical, biological and social factors are involved, so that progress demands the active co-operation of administrators, scientists, educationists and all those who live by the soil. In fact, the recommendations made will entail co-operation on a scale greater even than in the days of serious locust invasion, and with the difference that the work must continue tirelessly over a period of years instead of weeks. Sir Frank points out that no easy generalizations about control measures can be accepted; each area needs to be studied separately; and appropriate plans must be drawn up for its treatment before local works are begun. He points out that to encourage a cover of vegetation is the most obvious, natural and cheapest method of stopping erosion; but where cultivation exists on steep hillsides and strip-cropping is impossible, then contour ridges, terraces, hedges and drains are necessary. Such measures as these and others, without an improvement in the systems of agriculture and animal husbandry are however not enough, since they only provide for the present and not for the future. If the future is to be secured then the efforts made against erosion must be matched by equal efforts in the direction of agricultural education, demonstration and propaganda. The measures to be taken are thus national rather than local in their scope and the burden of paying for them must therefore not be grudged, since upon them the very existence of a population depends.

The report reveals a grave state of affairs that is very much more serious to East Africa in its consequences than any caused by temporary or chronic financial troubles; while, unlike some reports, its recommendations cannot be regarded as counsels of perfection and shelved in the hope that the problem will solve itself in time: it will not. Lest East Africans should feel unduly depressed by their erosion problems they should read the account of similar troubles elsewhere, particularly in the United States of America, and take heart from the fact that solutions are being found, although none that are easy.

A. G. G. H.

Current Notes

"Woodiness" Disease of Passion Fruit

"Woodiness" has been observed in the majority of established plantations in the Trans Nzoia and Sotik, and it gives every indication of becoming the Kenya producers' biggest problem. There is no "cure" for the disease, and therefore it behoves planters to take every possible step to prevent its introduction. "Woodiness" is caused by a virus and, apart from the well-known woody, misshapen fruits, is characterized by the usual symptoms of virus disease. Anyone acquainted with virus in potatoes will have no difficulty in recognizing infected vines even in the absence of woody fruits. The leaves, particularly in the region of the terminal shoots, are generally smaller than usual and twisted or puckered; also there is a pale mottling in the normal green colour of the leaves. These foliage symptoms can be recognized in seedlings. It is essential in the first place to select seed from old healthy vines and thereafter to carry out a rigorous inspection of the seedlings in the nursery. Infected plants must be removed immediately; this must be done carefully to avoid touching neighbouring plants. Healthy plants should not be touched by hands that have been in contact with the disease. This rule applies also in the field; on no account must boys be allowed to prune diseased vines. To remove vines in an old plantation the main stem should be ringbarked and left for a few days to die. Thereafter the entire vine should be dug up as completely as possible and removed. Since the virus is unlikely to be carried in the soil it will suffice merely to give the land several weeks rest before replanting a selected healthy seedling. This note is intended to warn prospective passion fruit growers that the control of "woodiness" must begin before the vines are planted out.

Black Chaff and Glume Blotch Diseases of Wheat

The severity of attack of Black Chaff, and to a much lesser degree Glume Blotch, on the early sown wheat crop in the Rift Valley Province of Kenya is worthy of consideration. The spread of these diseases is associated with wet conditions, and in 1937, from the start of the long rains in April until the end of August, no dry spell was experienced. The last occasion in which these diseases did appreciable damage was in 1932, also a wet year. They first appear soon after the crop is in ear; and whilst the early sown April crops were severely damaged, yielding only two or three bags of shrivelled grain, subsequent crops were progressively less attacked until yields of seven and eight bags of good grain were reaped from wheat sown barely a month later.

Briefly, Black Chaff may be recognized by the dark brown discoloration in the form of stripes on the culms, the neck just below the ear, and the chaff. Glume Blotch causes discoloration of the nodes and the chaff, which, however, has a roughened appearance and is not smooth and shiny as in the case of Black Chaff. Furthermore, only the nodes are blackened and not the whole culm.

Black Chaff is by far the more serious disease of the two. Wheat varieties vary in their susceptibility to it, though complete resistance has not been observed in Kenya. Sabanero wheat, for instance, under moderate infection suffers less damage than wheat No. 58, though in a very severe infection only shrivelled grain is harvested.

As the disease can be carried on the grain it is not advisable to sow seed from

an infected crop. No conclusive data have been obtained as to whether the disease is also soil borne.

It is not suggested that wheat growers should make a practice of late planting to avoid these diseases, but very early sowings are more liable to be damaged if a wet season is experienced.

Feeding of Dairy Cattle

Farmers frequently state that, in spite of feeding succulent roughages such as green oats, cowpeas, peas or Napier grass, when the grasses commence to dry up, milk yields fall very considerably and continue to do so in spite of the feeding. In many cases this is due to the fact that the cows are only fed while milking and have not time to consume a quantity likely to have any appreciable effect on yields, particularly when five or six cows have to be milked consecutively in one standing. For this reason it is recommended that either the green forage should be spread out on the night paddocks or, if the cattle are kept in a *boma* at night, then it should be fed in specially constructed racks fixed to the sides of the *boma*. When scattered on the paddocks, it should be spread out in a long line, so as to prevent the stronger cows from horning others away; where racks are used, plenty of space should be provided and they should be put at such a height that the cows have to pull the material downwards. This reduces waste and again helps to prevent them from horning each other away.

On maize farms at this time of year it is very desirable to allow the milking herd access to the harvested field for a few hours daily so as to feed on the trash. They will also assist in breaking it down, which is very desirable if it is to be ploughed in.

Dry Sows

While it is recognized that dry sows require very little additional feeding in this country provided they have free access to pasture and a small grain ration, yet it nearly always pays, unless they are in exceptionally good condition, to commence feeding the suckling ration well before farrowing. For sows in poor condition or those which have had one litter only, this may be commenced up to three weeks before farrowing and should be rapidly increased until 10 lb. per day is being fed. The mixture should contain, in addition to the usual proportions of maize meal, barley meal and pollards, and minerals, at least 15 per cent of bran, which is a milk stimulant and assists appreciably during the suckling period. Skim milk should also be fed during this period; or, where this is not available, some other protein-rich food, such as meat and bone meal.

Reversion of Arable Lands to Grass

A large-scale experiment is being carried out at Njoro on the establishment of grassland on arable land which has been cultivated for a large number of years and become low in fertility. The establishment of grass has proved to be rapid, both by natural reversion and by the planting of seeds and runners of suitable grasses. The outstanding plots are those planted with runners of Star grass, on which the stock-carrying capacity is high and is likely to approximate two beasts per acre when the results for the year are available. This experiment already indicates the value of a system of alternate grass and arable farming as a means of restoring fertility and for providing grazing of high stock-carrying capacity.

R. J. L.

Wool

Much information of interest to flock-masters is contained in Dalgety's Annual Wool Review for 1936-37. The review runs on an optimistic note, as is natural in a year in which the Board of Trade index of raw wool prices rose from 115 to 165.

In the United Kingdom general recovery, rearmament and the Coronation combined to stimulate activity in the wool textile industry. The season was marked by the recovery in the Continental demand, which had been curtailed by the depression, by the German embargo and control measures in Italy. Increased demand came from France, Germany, Belgium, Russia and Italy. American interest, too, was lively, demand being so high that wool imports were enabled to climb the high tariff wall.

An interesting illustration of the nature of world trade arose out of a tariff dispute between Australia and Japan. Japan suspended purchase in Australia during seven months of the selling season. During 1936 her purchases from Australia dropped by 74 million lb. However, purchases from New Zealand rose by 16.5 million lb. during the season, and purchases from South Africa by little short of 38.7 million lb. during the period of the dispute. During the period October, 1936, to March, 1937, purchases from Argentina and Uruguay rose by 35 million lb. over the same period of the previous season.

In fact all that happened was a reshuffling of the channels of trade. The position appeared easier in that world demand was able to cope with world supply, but if conditions had been otherwise we may hazard a guess that, even supposing there had been a surplus of wool on the market, weak selling by Australia in markets other than Japan would have gone a long way towards neutralizing the initial advantage of other countries in the Japanese market. The surface of connected bodies of water tends towards a common level.

Though world rayon production rose from 27 million lb. before the War to 1,309 million lb. of rayon in 1936, with 264 million lb. of "staple fibre" in addition, yet wool consumption has continued to increase and world consumption of cotton was on a higher level than in any previous season. It appears that new inventions have been accompanied by new uses.

V. L.

An Analysis of the Kenya Agricultural Census of 1936

By V. LIVERSAGE, *B.Sc., M.S. (Wis.), N.D.A., Agricultural Economist, Department of Agriculture, Kenya Colony.*

The ordinary census report has already been published. It deals with the farming land occupied by European farmers and planters, and gives the area occupied, under cultivation and under various crops, numbers of live stock, amounts of plant and animal products produced, and numbers employed in the industry. The particulars are given by agricultural districts or zones.

Much of the information contained in the returns is not brought out by the ordinary tabulation methods, and the purpose of the following analysis is to increase the range of information yielded. This is done by means of a classification of returns into farm types.

The method of tabulation adopted has been designed to facilitate the statistical work. It consists in breaking down the mass into a considerable number of small groups, according to the size of farm considered as a business unit, the kind and extent of particular crops grown, the kind and numbers of live stock kept, the apparent purpose for which live stock were kept, the amounts of animal produce sold, etc. The figures obtained for small groups were then combined into appropriate larger groups. The results are not always quite the same as those which would be yielded by separate *ad hoc* studies. For instance, very small quantities, such as less than 5 acres of coffee or 10 acres of annual field crops, etc., have been neglected in classification. Farms with such small areas remain scattered among other types and in this way the areas escape tabulation. Hence various totals do not quite agree with the figures given in the census report. These small omissions and discrepancies have no important effect on the practical value of the statistics.

CLASSIFICATION OF FARMS

The farms are divided into five main classes: crop farms, mixed farms, live stock farms, miscellaneous and nondescript.

951 farms, or 52 per cent of the whole, were classed as crop farms, having no cattle other than work oxen.

517 farms, or 29 per cent, were classed as mixed farms. These had some cattle (other than work oxen) in addition to crops.

Live stock farms numbered 248, or 14 per cent. These had no crops other than crops grown for stock feed.

Miscellaneous holdings, numbering 7, were devoted exclusively to wattle-growing, poultry, rabbits, etc.

Nondescript holdings had no significant development of any kind and were presumably mainly residential. They numbered 84, or 5 per cent of the total.

The primary classification is shown in Table I. No exclusive classification of maize farms, wheat farms, coffee farms, etc., could be made owing to the extent to which more than one crop was grown on the same holding. In each case it may be taken that the amount of any crop or kind of live stock not suggested in the heading of the class is negligible. For instance, the number of live stock on crop farms is negligible; otherwise such farms would be placed in the "mixed" class. (Work oxen are not considered in this connexion.) Similarly, coffee, maize, wheat and dairy farms are those on which nothing else of any importance is undertaken; coffee-and-cattle farms are those

TABLE I
NUMBER OF FARMS OF VARIOUS TYPES

Index No.	Type of Farm	Number of Returns		
		Total	Small Farms	Large Farms
	Crop Farms—			
I	Coffee	401	79	322
II	Coffee and Maize	174	32	142
III	Coffee and Pyrethrum	16	2	14
IV	Coffee and Mixed Field Crops	57	13	44
V	Mixed Field Crops	109	68	41
VI	Pyrethrum	12	9	3
VII	Tea and Mixed Field Crops	8	1	7
VIII	Tea	14	1	13
IX	Maize	56	35	21
X	Wheat	29	21	8
XI	Coco-nuts	12	5	7
XII	Essential Oils	3	—	3
XIII	Fruit	6	4	2
XIV	Sugar	7	—	7
XV	Sisal	28	—	28
XVI	Sisal and Coffee	15	—	15
XVII	Sisal and Maize	4	—	4
	Mixed Farms—			
XVIII	Coffee and Cattle:			
	A. Dairy	14	2	12
	B. Non-dairy	33	1	32
XIX	Coffee, Maize and Cattle:			
	A. Dairy	31	—	31
	B. Non-dairy	74	8	66
XX	Coffee, Mixed Field Crops and Cattle:			
	A. Dairy	18	—	18
	B. Non-dairy	46	4	42
XXI	Maize and Cattle:			
	A. Dairy	19	6	13
	B. Non-dairy	29	12	17
XXII	Wheat and Cattle:			
	A. Dairy	14	6	8
	B. Non-dairy	8	4	4
XXIII	Pyrethrum and Cattle:			
	A. Dairy	30	15	15
	B. Non-dairy	5	5	—
XXIV	Mixed Field Crops and Cattle:			
	A. Dairy	119	28	91
	B. Non-dairy	70	32	38
XXV	Mixed Field Crops, Tea and Cattle:			
	A. Dairy	1	—	1
	B. Non-dairy	1	—	1
XXVI	Sisal, Mixed Field Crops and Cattle:			
	A. Dairy	3	—	3
	B. Non-dairy	2	—	2
	Live Stock Farms—			
XXVII	Dairy	153	79	74
XXVIII	Dairy and Sheep	42	3	39
XXIX	Cattle Raising	34	23	11
XXX	Cattle and Sheep Raising	13	5	8
XXXI	Sheep Raising	6	2	4
XXXII	Miscellaneous	7	3	4
XXXIII	Nondescript	84	84	—
	Total Crop Farms	951	270	681
	„ Mixed Farms	517	123	394
	„ Live Stock Farms	248	112	136
	„ Miscellaneous	7	3	4
	„ Nondescript	84	84	—
	GRAND TOTAL	1,807	592	1,215

which contain no other enterprise of any importance.

A certain reservation is necessary here, however. It was impossible to include all factors in the classification or the number of classes would have become unwieldy. Hence the factors included have been limited in the main to coffee, tea, sisal, maize, wheat, pyrethrum, and cattle. Certain other crops have been considered in regard to special types, e.g. coco-nuts, sugar and fruit. Sheep have been brought into the classification on live stock farms only. Poultry and pigs have not been brought in at all. Hence some crop and mixed farms might have small areas of barley, beans, potatoes, etc., in addition to the crops indicated in the title, or some sheep, pigs, or poultry. In the case of sheep, it was ascertained that the number kept on mixed farms was of no great significance from a classification point of view. Pigs and poultry are found on farms of all types, but in scarcely any do they attain any particular significance.

Dairy farms are those for which sales of dairy produce in significant amounts were shown.

Table II shows the area covered by the various farm types.

Size of Farm Businesses

The farms were classified into large and small farms, as measured not by total area but according to probable annual turnover. The classification was necessarily rough, and was based on production capacity under average conditions. The dividing line was taken at the following:

Coffee, tea, or pyrethrum	50 acres
Cereal crops or sisal ..	250 acres
Dairy cows	100
Non-dairy cows	250
Grade or pure-bred ewes	1,000

Proportional values for each kind of crop or live stock were assigned when classifying farms with diversified production. Minor products such as pigs, poultry, vegetables, etc., were neglected. In certain localities these may be important, but taking the agriculture of the Colony as a whole little modification of the general conclusions is necessary on account of their omission. Those farms falling below the dividing line are styled "small" farms for the sake of brevity, and the remainder as "large" farms, though the adjectival significance of these terms is not very precise.

Price relationships have changed even since the above scheme of size-classification was drawn up. The classification is designed primarily for simplicity, and does not pretend to be a scientific scale of economic equivalents. There is no strict compatibility between fifty acres of coffee, the same acreage of tea or pyrethrum, 250 acres of maize, 250 acres of sisal, and 250 non-dairy cows. It can be said, however, that any farm with less than the equivalents mentioned is a small farm, considered as an economic proposition. Very few of such farms would be likely to return annual gross receipts of as much as £1,000, even on a liberal estimate. For instance, 50 acres of coffee at 4 cwt. per acre and £70 per ton f.o.r. yields only £700. One hundred dairy cows, yielding 60 lb. of butterfat each per annum, at Sh. 1 per lb., yield only £300, plus, perhaps, a similar amount from sale of natural increase and some value in the form of separated milk for pig feeding. 250 acres of maize at 8 bags per acre must sell at Sh. 10 per bag on the farm to yield £1,000.

If the gross output is on this scale, the net output must be much smaller. Insufficient knowledge of costs is available to form reliable estimates of net output for the acreages of crops and numbers of live stock mentioned. Most of the "costs of production" which have been put forward at various times include items like

TABLE II

TOTAL AREA OCCUPIED IN FARMS OF VARIOUS TYPES

Index No.	Type of Farm	Area Occupied		
		Total	Small Farms	Large Farms
		Acres	*Acres*	*Acres*
	Crop Farms—			
I	Coffee	347,748	43,344	304,404
II	Coffee and Maize	212,424	21,320	191,104
III	Coffee and Pyrethrum	9,345	274	9,071
IV	Coffee and Mixed Field Crops	85,310	11,523	73,787
V	Mixed Field Crops	159,960	63,922	96,038
VI	Pyrethrum	5,666	2,855	2,811
VII	Tea and Mixed Field Crops	3,984	300	3,684
VIII	Tea	51,997	556	51,441
IX	Maize	76,120	37,285	38,835
X	Wheat	38,749	23,122	15,627
XI	Coco-nuts	13,891	2,484	11,407
XII	Essential Oils	3,465	—	3,465
XIII	Fruit	5,493	1,643	3,850
XIV	Sugar	31,384	—	31,384
XV	Sisal	304,274	—	304,274
XVI	Sisal and Coffee	81,820	—	81,820
XVII	Sisal and Maize	38,538	—	38,538
	Mixed Farms—			
XVIII	Coffee and Cattle :			
	A. Dairy	34,365	3,700	30,665
	B. Non-dairy	43,471	200	43,271
XIX	Coffee, Maize and Cattle :			
	A. Dairy	80,278	—	80,278
	B. Non-dairy	128,202	6,201	122,001
XX	Coffee, Mixed Field Crops and Cattle :			
	A. Dairy	30,373	—	30,373
	B. Non-dairy	86,312	1,648	84,664
XXI	Maize and Cattle :			
	A. Dairy	222,333	5,089	217,244
	B. Non-dairy	70,425	23,365	47,060
XXII	Wheat and Cattle :			
	A. Dairy	44,855	15,995	28,860
	B. Non-dairy	15,868	7,579	8,289
XXIII	Pyrethrum and Cattle :			
	A. Dairy	53,401	18,358	35,043
	B. Non-dairy	4,285	4,285	—
XXIV	Mixed Field Crops and Cattle :			
	A. Dairy	417,131	38,088	379,043
	B. Non-dairy	157,317	40,532	166,785
XXV	Mixed Field Crops, Tea and Cattle :			
	A. Dairy	980	—	980
	B. Non-dairy	289	—	289
XXVI	Sisal, Mixed Field Crops and Cattle :			
	A. Dairy	30,916	—	30,916
	B. Non-dairy	37,570	—	37,570
	Live Stock Farms—			
XXVII	Dairy	457,716	105,569	352,147
XXVIII	Dairy and Sheep	483,513	5,085	478,428
XXIX	Cattle Raising	172,104	62,480	109,624
XXX	Cattle and Sheep Raising	146,133	7,363	138,770
XXXI	Sheep Raising	150,090	4,009	146,081
XXXII	Miscellaneous	3,031	690	2,341
XXXIII	Nondescript	238,903	238,903	—
	Total Crop Farms	1,470,168	208,628	1,261,540
	„ Mixed Farms	1,458,371	165,040	1,293,331
	„ Live Stock Farms	1,409,556	184,506	1,225,050
	„ Miscellaneous	3,031	690	2,341
	„ Nondescript	238,903	238,903	—
	GRAND TOTAL	4,580,029	797,767	3,782,262

interest on capital and owner's remuneration for management, which are not relevant in the present connexion.

Reference to Table I shows that no fewer than 592 farms, or 33 per cent of the total, fall into the small class. Small coffee farms number 79, small dairy farms 68, small farms growing a mixture of field crops 68, and "nondescript" holdings 84.

From Table II it will be seen that the small farms cover 797,767 acres or 17 per cent of the total occupied area. The average area of the small farms is thus approximately 1,350 acres, as compared with an average of 3,100 acres in the "large" group.

Coffee

An analysis of the main classes of farms producing coffee is shown in Table III. The table shows that there were 880 farms producing coffee. This enumeration does not include farms with less than 5 acres under coffee.

Of the total number, 401 were devoted to coffee alone, while 479 had some other enterprise in addition, either other crops, cattle or a combination of the two.

On the 263 farms on which coffee was combined with other crops only, i.e. without cattle husbandry, the supplementary crop was maize in 174 cases, pyrethrum in 16, a combination of field crops in 57, and sisal in 15. There was also one farm on which it was combined with tea.

On 216 farms coffee was combined with cattle husbandry. On 47 of these, coffee and cattle husbandry were the sole enterprises. On 105 farms coffee was combined with maize and cattle husbandry, and 64 farms had a combination of crops and cattle husbandry.

Of the coffee farms enumerated, 141 were in the "small" class and 739 in the "large" class. On farms with coffee alone the dividing line was 50 acres of coffee, and from the table it will be seen that of 401 farms with coffee alone 79 had less than 50 acres. In the other classes, however, all lines of production are taken into account in deciding whether a particular farm is to be placed in the "small" or "large" class. If attention is confined to coffee, the following facts emerge:—

*TABLE III(*a*)

Number of Farms Growing Acreages of Coffee Within the Under-mentioned Limits

Type of Farm	5–49 Acres	50–149 Acres	150–249 Acres	250 Acres and over	Total
	No.	*No.*	*No.*	*No.*	*No.*
Coffee Alone	79	172	100	50	401
Coffee and other Crops	109	112	28	14	263
Coffee, Other Crops and Cattle ..	82	89	29	16	216
Total ..	270	373	157	80	880

*The Agricultural Census gave the figures of acreage and production of clean coffee as 101,234 acres and 386,827 cwt. respectively. In the above classification, therefore, 1,144 acres and 2,476 cwt. were excluded. Those figures represent small plantations of less than 5 acres, which were not considered in classification and are therefore distributed among other farm types.

*TABLE III(*b*)

TOTAL AREA OF COFFEE ON FARMS AS ABOVE

TYPE OF FARM	5–49 Acres	50–149 Acres	150–249 Acres	250 Acres and Over	Total
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
Coffee Alone	2,537	16,213	18,879	20,204	57,833
Coffee and Other Crops	1,835	9,323	5,388	4,922	21,468
Coffee, Other Crops and Cattle ..	1,991	7,877	5,234	5,687	20,789
TOTAL ..	6,363	33,413	29,501	30,813	100,090

*TABLE III(*c*)

CLEAN COFFEE PRODUCED ON FARMS AS ABOVE

TYPE OF FARM	5–49 Acres	50–149 Acres	150–249 Acres	250 Acres and Over	Total
	Cwt.	*Cwt.*	*Cwt.*	*Cwt.*	*Cwt.*
Coffee Alone	6,993	63,828	93,666	106,197	270,684
Coffee and Other Crops	1,840	17,535	14,637	19,614	53,626
Coffee, Other Crops and Cattle ..	4,519	18,117	17,953	19,452	60,041
TOTAL ..	13,352	99,480	126,256	145,263	384,351

*The Agricultural Census gave the figures of acreage and production of clean coffee as 101,234 acres and 386,827 cwt. respectively. In the above classification, therefore, 1,144 acres and 2,476 cwt. were excluded. Those figures represent small plantations of less than 5 acres, which were not considered in classification and are therefore distributed among other farm types.

It will be seen that 270 farms out of 880, or approximately 31 per cent, had less than 50 acres of coffee, the average acreage on the 270 farms being actually 24. The greatest number, 42 per cent of the total, is found in the 50 to 149 acre group, where the average acreage was 90 acres.

Specialized coffee farms, numbering 401, accounted for 58 per cent of the coffee acreage and 70 per cent of the coffee produced. The remaining 479 farms had 42 per cent of the acreage, but produced only 30 per cent of the coffee. Specialized coffee farms with over 50 acres of coffee, numbering 322, accounted for 55 per cent of the coffee acreage, and 69 per cent of the total production.

MAIZE

A considerable number of maize-growing farms are included in the mixed classes in Tables I and II. These were separated for tabulation.

Maize-growing farms numbered 735 in all, including 206 "small" farms and 529 "large". The "small" farms grew a total of 13,340 acres[1] of maize, as compared with 102,793 acres[1] on the "large" farms. The production of maize was 101,566 bags[1] of 200 lb. (7.6 bags per acre) on the "small" farms and 884,045 bags[1] (8.6 bags per acre) on the "large".

[1] The figures given in the Agricultural Census are 117,848 acres and 1,011,863 bags, so that 1,715 acres and 26,252 bags escaped the above tabulation.

On 56 farms maize was the sole enterprise. These farms showed a total of 76,120 acres under occupation, 11,980 acres under maize, and a production of 109,464 bags of maize. On 48 farms maize was the only crop grown, but was combined with cattle husbandry; on these the acreage of maize harvested was 10,859 and the yield 78,102 bags. Farms on which maize and coffee were the only crops numbered 279, of which 174 were crop farms and 105 had cattle husbandry as well; these grew 16,495 acres of maize and produced 143,766 bags. On the other maize farms maize-growing was combined with sisal or a mixture of general crops, with or without live stock.

Some significance attaches to the distribution of maize-growing in relation to plantations which might be regarded in the ordinary way as consumers of maize. In all, 392 farms out of a total of 880 on which coffee was grown had maize in addition; the total acreage of maize concerned was 56,721 and the production 521,354 bags. Thus 53 per cent of the maize farms, 50 per cent of the maize acreage, and 52 per cent of the maize grain produced on European farms in the Colony was directly linked with coffee production. A further area of 2,953 acres and 16,409 bags was associated with sisal.

The average area of maize harvested per farm was 158 acres of all farm types, being 65 on the "small" farms and 194 on the "large" farms. On "crop" farms the average was 142 acres, 73 on the "small" farms and 181 on the "large". On the "mixed" farms the average was 176 acres, 48 on the "small" and 207 on the "large" farms.

Among individual farm types, the highest average was for 4 farms growing sisal and maize, the figure being 656 acres. Next came 2 "maize-and-cattle (dairy)" farms, averaging 500 acres under maize. Next came a group of 17 "large" farms combining maize and cattle (non-dairy), with an average of 487 acres. The next averages in point of size were one of 350 acres for 37 "large" farms growing maize alone, one of 310 acres for two "large" "coffee-mixed-crops-and-dairy" farms, one of 303 acres for a group of 33 "large" "mixed-crops-and-non-dairy-cattle" farms, and one of 246 acres for a group of 37 "large" mixed-crop farms.

The groups mentioned in the foregoing paragraph account for a total of 132 maize farms out of the 735. The classification into "large" and "small" farms was made by taking all the chief forms of development into account and no classification of farms by acreage under maize was made. Hence some of the farms classed as "large" may have had only small acreages under maize, with the result that the average of the group is reduced. Farms classed as "small" may have had up to 250 acres of maize. However, the figures probably give a fair indication of the general run of maize acreages. According to them, only 132 maize-growing farms appeared in groups showing averages of over 245 acres of maize, and 603 farms appeared in groups with averages below this figure. The highest individual group average in the groups below 245 acres was actually 218 acres, individual group averages ranging down to 27 acres. Groups including 185 farms showed averages of less than 100 acres of maize.

It is thus evident that relatively few farms are engaged in maize production on any extensive scale.

Wheat

In the case of wheat, again, a large proportion of the farms on which wheat was grown was included in the various mixed-crop classes. The total number of farms growing wheat was 353.

As will be seen from Table I, 29 farms grew wheat alone, and 22 combined wheat with animal husbandry. On other farms, wheat was grown along with other crops, and was included under the heading of mixed crops.

Of the total number of farms on which wheat was grown, 12 had wheat acreages of 500 or over, grew 10,152 acres and produced 35,078 bags; 44 farms with acreages of 250 to 499 grew 14,506 acres and produced 37,560 bags. Thus 297 farms with less than 250 acres grew 27,477 acres and produced 80,326 bags.

The season was notable for severe attacks of rust, and the acreage of wheat harvested is consequently a better guide to distribution than yield. Expressing the numbers of farms and the acreages of wheat as percentages, we have the following:—

TABLE IV

Acreage of Wheat per Farm	No. of Farms	Total Acreage of Wheat	Average Acreage per Farm	Percentage of Total	
				No. of Farms	Acreage of Wheat
Under 250	297	27,444	92	84	53
250–499	44	14,506	330	12	28
500 and Over	12	10,152	846	4	19
Total	353	52,102	1,268	100	100

"Mixed" farms as a whole accounted for 1,458,371 acres occupied; the area under cultivation was 162,896 acres, and the area of crops grown 149,526 acres. They carried 37,885 cows and heifers over three years old, and 34,959 grade and pure-bred breeding ewes. The output of dairy produce amounted to the equivalent of 1,346,700 lb. of butterfat.

The significance of these figures can be best appreciated by comparing them with the totals for the Colony:—

TABLE V

	Total for Colony	Mixed Farms	Percentage of Mixed Farms to Total
Number of Farms	1,807	517	29
Acres Occupied	4,580,029	1,458,371	32
Acres Cultivated	502,497	162,896	32
Acres of Crops	480,300	149,526	31
Cows and Heifers over 3 Years	86,787	37,885	44
Grade and Purebred Breeding Ewes	104,381	34,959	33
Total Butterfat Equivalent Sold	2,824,288	1,346,700	48

Thus, 56 growers, or 16 per cent of the total number, grew nearly half the wheat in the Colony.

Mixed Farming

Special interest attaches to the mixed-crop-and-live-stock farms, in view of the importance of soil conservation and of broadening the base of farming operations.

The total number classed as "mixed" farms was 517, or 29 per cent of the total of all farms. A similar classification was made in 1932 and the number at that time was only 251 or 12 per cent of the total. A fair measure of progress has thus been achieved in the direction of mixed farming.

It will be seen that in point of numbers and acreage "mixed" farms comprise roughly one-third of the total, but that in point of cattle husbandry and dairy produce sold they reach proportions more nearly approaching one-half.

The comparative figures of large and small mixed farms were as follows:—

TABLE VI

	Small Farms	Large Farms
Number of Farms	123	394
Acres Occupied	165,040	1,293,331
Acres Cultivated	12,518	150,378
Acres of Crops	10,510	139,016
Cows and Heifers over 3 years	4,573	33,312
Total Butter Equivalent Sold lb.	115,898	1,230,802
Grade and Purebred Breeding Ewes	1,861	33,098

It is useful to see what these figures indicate when expressed in terms of the average farm. The figures per farm are given below:—

TABLE VII

	Small Farms	Large Farms	Ratio of Large to Small Farms
Acres Occupied	1,342	3,282	2·4
Acres Cultivated . ..	102	382	3·8
Acres of Crops	85	353	4·2
Cows and Heifers Over 3 Years	37	85	2·3
Total Butterfat Equivalent Sold, lb.	942	3,123	3·3
Grade and Purebred Breeding Ewes ..	15	84	5·6

It will be seen that the discrepancy between the degree of development on the "small" and the "large" farms is appreciable. The figures given in the right-hand column show for the various items the ratio between the "large" and the "small" farm. While the "large" farm had on the average 2.4 times the acreage of the "small" farm, it had 4.2 times the area under crops, 2.3 times the number of cows and heifers over three years old, sold 3.3 times the amount of dairy produce, and carried 5.6 times the number of grade and pure-bred breeding ewes.

Dairying

The total number of dairy farms was 444. As in the other divisions, very small amounts of dairy produce were neglected in classification.

The number of dairy farms in the main classes, with the area occupied, the number of cows and heifers over three years, and the total quantity of dairy produce sold, in terms of butterfat, were as follows:—

TABLE VIII

	No. of Farms	Acres Occupied	No. of Cows and Heifers Over 3 Years	Butterfat Equivalent
				lb.
"Mixed" Farms ..	249	914,632	28,412	1,348,890
"Live Stock" Farms ..	195	941,229	35,188	1,419,374
Total ..	444	1,855,861	63,600	2,768,264

All farms returning significant amounts of dairy produce sold were classed as dairy farms, and the number thus includes farms that may be mainly cattle-raising propositions on which a quantity of milk surplus to rearing requirements is available.

Dairy farms falling into the "small" class, numbering 139, accounted for 191,884 acres occupied, had 6.176 cows and heifers over three years, and produced the equivalent of 374,209 lb. of butterfat for sale. In terms of the average per farm these figures amount to 1,380 acres occupied, 45 cows and 2,690 lb. of butterfat.

Those falling into the "large" class numbered 305, with 1,663,977 occupied acres and 57,424 cows and heifers over three years, producing 2,394,055 lb. of butterfat equivalent. The average farm in this class thus had an area of 5,456 acres, carried 188 cows and produced 7,850 lb. of butterfat equivalent.

Here again, other enterprises have been taken into account in differentiating between small and large farms. If attention is confined to the dairy produce sold, the following figures emerge:—

TABLE IX

	No.	Butterfat Equivalent	Cows and Heifers Over 3 Years
		lb.	*No.*
Farms Producing Under 5,000 lb. Butterfat Equivalent	290	756,264	23,244
Farms Producing Over 5,000 lb. Butterfat Equivalent	154	2,012,000	40,356
Total ..	444	2,768,264	63,600

Sales of dairy produce per cow, converted to the equivalent of butterfat, averaged 43.5 lb. This figure does not represent the total yield per cow, but the surplus after the requirements for calf-rearing and home consumption have been satisfied. The corresponding figure in 1932 was 32 lb.

The yields per cow in the main classes of farms are given below, the figures in brackets indicating the number of farms on which the averages are based:—

TABLE X

	Small Farms	Large Farms	All Farms
Mixed Farms with Coffee	16·3 (2)	52·8 (61)	52·0 (63)
Other Mixed Farms	51·3 (55)	46·2 (131)	46·6 (186)
Live Stock Farms	67·0 (82)	37·1 (113)	40·3 (195)
All Dairy Farms	60·6 (139)	41·7 (305)	43·5 (444)

The averages in the "small" groups are brought up by a proportion of intensively farmed concerns, mostly near towns. The great bulk of the dairy cows in the Colony were returned in the "large" farms classed in Tables X and XI as "Other Mixed Farms" and "Live Stock Farms", where the averages were 46.6 lb. and 40.3 lb. respectively.

The area under fodder crops is important in relation to dairy development. The area returned in the year under review amounted to 11,363 acres. This was distributed as follows:—

TABLE XI

Type of Farm	Farms Producing Under 5,000 lb. Butterfat Equivalent	Farms Producing Over 5,000 lb. Butterfat Equivalent
	Acres	*Acres*
Mixed Farms with Coffee	1,029	85
Other Mixed Farms	4,990	3,203
Live Stock Farms	437	1,619
Total ..	6,456	4,907

On the "live stock" farms producing over 5,000 lb. of butterfat, the acreage under fodder crops was thus sufficient to provide for 0.07 acres per cow. Assuming a dry season of four months and a yield of 10 tons of forage per acre, this would provide a ration of 13 lb. of forage per cow per day.

In the group of "mixed" farms not growing coffee, with a production of over 5,000 lb. of butterfat equivalent, a similar calculation would give a figure of 0.21 acres per cow, or approximately 40 lb. per cow per day.

Dairy farms returned a total of 67,623 grade and pure-bred breeding ewes, of which only 1,962 were returned by farms in the "small" class. The total for the Colony was 104,381, so that dairy farms accounted for 65 per cent of the total. "Large" "dairy-and-sheep" farms accounted for 35,714 and "large" "mixed-crop-and-cattle" farms for 17,615, leaving only 14,294 in the other groups of dairy farms.

Cattle and Sheep Raising

Farms classed as "cattle-raising" propositions numbered 34, of which 23 were classed as "small" and 11 as "large". In addition there were 13 farms classified as "cattle-and-sheep" raising, 5 "small" and 8 "large". "Sheep-raising" farms numbered 6, of which 2 were "small" and 4 "large".

These figures include only farms returning no significant sales of dairy produce, the others being dealt with in the previous section. In the following table therefore the figures relating to all classes of purely "live stock" farms are given:—

TABLE XII

Type of Farm	No. of Farms	Acres Occupied	Cows and Heifers Over 3 Years	Butterfat Equivalent Sold	Grade and Purebred Breeding Ewes
Non-dairy Farms—					
Cattle Raising	34	172,104	8,560	694	4
Cattle and Sheep Raising	13	146,133	3,292	678	19,268
Sheep Raising	6	150,090	—	—	12,089
Dairy Farms—					
Dairying (Grass)	153	457,716	21,100	1,022,974	947
Dairy and Sheep	42	483,513	14,088	396,400	36,294

Adult cattle slaughtered numbered the following:—

TABLE XIII

Type of Farm	Small Farms	Large Farms
	No.	*No.*
Cattle Raising	253	2,614
Cattle and Sheep Raising ..	1	729
Sheep Raising	—	—
Dairying (Grass)	397	3,002
Dairy and Sheep	2	1,802

Sheep slaughtered were as follows:—

TABLE XIV

Type of Farm	Small Farms	Large Farms
	No.	*No.*
Cattle Raising	—	—
Cattle and Sheep Raising ..	58	7,95
Sheep Raising	83	1,641
Dairying (Grass)	121	235
Dairy and Sheep	4	7,850

Wool sold was returned as follows:—

TABLE XV

Type of Farm	Small Farms	Large Farms
	lb.	*lb.*
Cattle Raising	—	—
Cattle and Sheep Raising ..	2,900	181,414
Sheep Raising	5,793	186,852
Dairying (Grass)	1,500	—
Dairy and Sheep	—	427,886

Live Stock Carried

The rate of stocking is shown in the table below (Table XVI). In compiling the table all live stock have been converted to a common basis of adult cattle equivalents in accordance with their nutritive requirements. The equivalents used were 1 head of cattle = 7 sheep or goats = 5 pigs = 1 horse. Young animals (calves, lambs) were taken at half the equivalent of mature animals. These equivalents have been worked out and used in other countries and represent, of course, only an approximation to fact. It is possible that the sheep equivalent is somewhat on the low side, owing to the common practice of burning grass before them. Figures relating to individual districts would of course be more useful, but this would considerably enlarge the scope of the present study and those given may provide a useful general indication.

The number of acres per cattle equivalent in the table is worked out on the total acreage *less* the acreage under cultivation.

TABLE XVI

LIVE STOCK CARRIED

Number of Acres (Excluding Arable Land) per "Cattle Equivalent"

Index No.	Type of Farm	Acres per Cattle Equivalent
XVIII	Coffee and Cattle:	
	A. Dairy	14·7
	B. Non-dairy	15·2
XIX	Coffee, Maize and Cattle:	
	A. Dairy	12·3
	B. Non-dairy	13·6
XX	Coffee, Mixed Field Crops and Cattle:	
	A. Dairy	6·6
	B. Non-dairy	6·0
XXI	Maize and Cattle:	
	A. Dairy	13·7
	B. Non-dairy	9·0
XXII	Wheat and Cattle:	
	A. Dairy	13·4
	B. Non-dairy	12·2
XXIII	Pyrethrum and Cattle:	
	A. Dairy	7·3
	B. Non-dairy	9·9
XXIV	Mixed Field Crops and Cattle:	
	A. Dairy	9·0
	B. Non-dairy	13·0
XXVII	Dairy	10·1
XXVIII	Dairy and Sheep	12·0
XXIX	Cattle Raising	8·4
XXX	Cattle and Sheep Raising ..	9·3
XXXI	Sheep Raising	30·6

Nondescript Holdings

A considerable proportion of the "nondescript" holdings are situated in the vicinity of Nairobi, Naivasha and Nakuru and are presumably mainly residential. The distribution by size-groups is shown below:—

Size-group Acres.	*No.*	*Total Acreage.*
0— 49	4	94
50— 149	12	1,042
150— 249	13	2,296
250— 499	14	4,815
500— 999	10	7,575
1,000—1,999	10	13,630
2,000—4,999	15	44,878
5,000 and over	6	164,573
Total	84	238,903

These holdings might be considered along with the holdings alienated but not occupied, totalling 2,048,451 acres, which are outside the scope of the Agricultural Census.

Labour

During the year under review the total native labour recorded was 1,262,448 monthly units of "regular" labour (i.e. on monthly ticket or longer period contract), and 185,388 units of casual labour. These figures correspond to the full-time yearly work of 105,204 and 15,449 persons respectively, a total of 120,653.

The distribution of labour among the various types of farm is shown in Tables XVII and XVIII.

From the tables the following items have been extracted. The figures are given in full-time labour units (i.e. whole year), and the number of farms on which the averages are based are given in brackets. Labour on chief products is as indicated by farms on which no other line of production was followed:—

		Regular	Casual
Coffee, per Acre Planted—			
Farms with under 50 acres of coffee	(79)	0·45	0·32
Farms with between 50 and 250 acres of coffee	(272)	0·46	0·19
Farms with over 250 acres of coffee	(50)	0·38	0·19
Sisal, per Acre Planted	(28)	1·19	—
Tea, per Acre Planted	(14)	0·81	—
Pyrethrum, per Acre Planted	(12)	0·68	0·24
Maize, per Acre Harvested—			
Small Farms	(35)	0·13	0·01
Large Farms	(21)	0·10	—
Wheat, per Acre Harvested—			
Small Farms	(21)	0·07	—
Large Farms	(8)	0·03	—
Dairying (Live Stock Farms)—			
Per Cow*—			
Small Farms	(79)	0·26	0·01
Large Farms	(74)	0·12	—
Cattle Raising (on Grass)			
Per Cow*—			
Small Farms	(23)	0·27	0·01
Large Farms	(11)	0·03	—
Sheep Raising, per Breeding Ewe*—			
Small Farms	(2)	0·014	—
Large Farms	(4)	0·013	—

*With its complement of other stock.

TABLE XVII
REGULAR LABOUR

Index No.	Type of Farm	Monthly Units		
		Total	Small Farms	Large Farms
	Crop Farms—			
I	Coffee	298,666	13,667	284,999
II	Coffee and Maize	114,063	11,188	102,875
III	Coffee and Pyrethrum	12,435	302	12,133
IV	Coffee and Mixed Field Crops	49,506	9,589	39,917
V	Mixed Field Crops	33,603	13,017	20,586
VI	Pyrethrum	3,099	1,820	1,279
VII	Tea and Mixed Field Crops	6,329	383	5,946
VIII	Tea	116,873	200	116,673
IX	Maize	16,320	7,119	9,201
X	Wheat	3,233	2,149	1,084
XI	Coco-nuts	3,035	1,302	1,733
XII	Essential Oils	2,729	—	2,729
XIII	Fruit	1,911	536	1,375
XIV	Sugar	30,477	—	30,477
XV	Sisal	107,085	—	107,085
XVI	Sisal and Coffee	52,953	—	52,953
XVII	Sisal and Maize	13,785	—	13,785
	Mixed Farms—			
XVIII	Coffee and Cattle :			
	A. Dairy	9,750	230	9,520
	B. Non-dairy	24,651	52	24,599
XIX	Coffee, Maize and Cattle :			
	A. Dairy	19,304	—	19,304
	B. Non-dairy	53,078	2,224	50,854
XX	Coffee, Mixed Field Crops and Cattle :			
	A. Dairy	12,186	—	12,186
	B. Non-dairy	36,492	2,032	34,460
XXI	Maize and Cattle :			
	A. Dairy	12,975	1,559	11,416
	B. Non-dairy	13,012	3,293	9,719
XXII	Wheat and Cattle :			
	A. Dairy	3,264	1,223	2,041
	B. Non-dairy	2,253	746	1,507
XXIII	Pyrethrum and Cattle :			
	A. Dairy	10,131	2,974	7,157
	B. Non-dairy	1,919	1,919	—
XXIV	Mixed Field Crops and Cattle :			
	A. Dairy	60,618	6,292	54,326
	B. Non-dairy	25,026	5,276	19,930
XXV	Mixed Field Crops, Tea and Cattle :			
	A. Dairy	759	—	759
	B. Non-dairy	420	—	420
XXVI	Sisal, Mixed Field Crops and Cattle :			
	A. Dairy	13,684	—	13,684
	B. Non-dairy	8,335	—	8,335
	Live Stock Farms—			
XXVII	Dairy	36,944	11,770	25,174
XXVIII	Dairy and Sheep	24,445	729	23,716
XXIX	Cattle Raising	6,959	4,207	2,752
XXX	Cattle and Sheep Raising	6,547	603	5,944
XXXI	Sheep Raising	1,875	106	1,769
XXXII	Miscellaneous	831	437	394
XXXIII	Nondescript	10,708	10,708	—
	Total Crop Farms	866,102	61,272	804,830
	„ Mixed Farms	308,037	27,820	280,217
	„ Live Stock Farms	76,770	17,415	59,355
	„ Miscellaneous	831	437	394
	„ Nondescript	10,708	10,708	—
	GRAND TOTAL	1,262,448	117,652	1,144,796

TABLE XVIII
CASUAL LABOUR

Index No.	Type of Farm	Monthly Units		
		Total	Small Farms	Large Farms
	Crop Farms—			
I	Coffee	134,917	9,645	125,272
II	Coffee and Maize	5,991	128	5,863
III	Coffee and Pyrethrum	11,473	126	11,347
IV	Coffee and Mixed Field Crops	2,890	899	1,991
V	Mixed Field Crops	713	516	197
VI	Pyrethrum	1,111	597	514
VII	Tea and Mixed Field Crops	977	—	977
VIII	Tea	—	—	—
IX	Maize	500	394	106
X	Wheat	238	122	116
XI	Coco-nuts	79	25	54
XII	Essential Oils	147	—	147
XIII	Fruit	15	15	—
XIV	Sugar	1,094	—	1,094
XV	Sisal	—	—	—
XVI	Sisal and Coffee	2,645	—	2,645
XVII	Sisal and Maize	—	—	—
	Mixed Farms—			
XVIII	Coffee and Cattle :			
	A. Dairy	400	—	400
	B. Non-dairy	5,020	27	4,993
XIX	Coffee, Maize and Cattle :			
	A. Dairy	2,019	—	2,019
	B. Non-dairy	2,064	77	1,987
XX	Coffee, Mixed Field Crops and Cattle :			
	A. Dairy	1,222	—	1,222
	B. Non-dairy	2,159	8	2,151
XXI	Maize and Cattle :			
	A. Dairy	622	—	622
	B. Non-dairy	434	328	106
XXII	Wheat and Cattle :			
	A. Dairy	75	40	35
	B. Non-dairy	—	—	—
XXIII	Pyrethrum and Cattle :			
	A. Dairy	2,315	390	1,925
	B. Non-dairy	—	—	—
XXIV	Mixed Field Crops and Cattle :			
	A. Dairy	3,434	83	3,351
	B. Non-dairy	774	319	455
XXV	Mixed Field Crops, Tea and Cattle :			
	A. Dairy	396	—	396
	B. Non-dairy	120	—	120
XXVI	Sisal, Mixed Field Crops and Cattle :			
	A. Dairy	144	—	144
	B. Non-dairy	—	—	—
	Live Stock Farms—			
XXVII	Dairy	467	465	2
XXVIII	Dairy and Sheep	119	—	119
XXIX	Cattle Raising	450	117	333
XXX	Cattle and Sheep Raising	73	—	73
XXXI	Sheep Raising	—	—	—
XXXII	Miscellaneous	—	—	—
XXXIII	Nondescript	291	291	—
	Total Crop Farms	162,790	12,467	150,323
	„ Mixed Farms	21,198	1,272	19,926
	„ Live Stock Farms	1,109	582	527
	„ Miscellaneous	—	—	—
	„ Nondescript	291	291	—
	GRAND TOTAL	185,388	14,612	170,776

Squatters

The distribution of squatters and their cattle by farm types is shown in Tables XIX and XX.

TABLE XIX

NUMBER OF MALE SQUATTERS RESIDENT ON FARMS OF VARIOUS TYPES

Index No.	Type of Farm	Total	Small Farms	Large Farms
	Crop Farms—			
I	Coffee	4,295	386	3,909
II	Coffee and Maize	2,491	132	2,359
III	Coffee and Pyrethrum	265	6	259
IV	Coffee and Mixed Field Crops	1,247	430	817
V	Mixed Field Crops	1,247	588	659
VI	Pyrethrum	151	56	95
VII	Tea and Mixed Field Crops	72	—	72
VIII	Tea	609	23	586
IX	Maize	512	281	231
X	Wheat	212	134	78
XI	Coco-nuts	—	—	—
XII	Essential Oils	33	—	33
XIII	Fruit	31	6	25
XIV	Sugar	94	—	94
XV	Sisal	624	—	624
XVI	Sisal and Coffee	504	—	504
XVII	Sisal and Maize	235	—	235
	Mixed Farms—			
XVIII	Coffee and Cattle:			
	A. Dairy	420	22	398
	B. Non-dairy	396	—	396
XIX	Coffee, Maize and Cattle:			
	A. Dairy	710	—	710
	B. Non-dairy	1,347	39	1,308
XX	Coffee, Mixed Field Crops and Cattle:			
	A. Dairy	73	—	73
	B. Non-dairy	636	13	623
XXI	Maize and Cattle:			
	A. Dairy	538	89	449
	B. Non-dairy	550	137	413
XXII	Wheat and Cattle:			
	A. Dairy	227	146	81
	B. Non-dairy	104	64	40
XXIII	Pyrethrum and Cattle:			
	A. Dairy	507	114	393
	B. Non-dairy	133	133	—
XXIV	Mixed Field Crops and Cattle:			
	A. Dairy	2,387	243	2,144
	B. Non-dairy	1,093	255	838
XXV	Mixed Field Crops, Tea and Cattle:			
	A. Dairy	57	—	57
	B. Non-dairy	25	—	25
XXVI	Sisal, Mixed Field Crops and Cattle:			
	A. Dairy	300	—	300
	B. Non-dairy	34	—	34
	Live Stock Farms—			
XXVII	Dairy	1,096	305	791
XXVIII	Dairy and Sheep	826	6	820
XXIX	Cattle Raising	267	103	164
XXX	Cattle and Sheep Raising	153	15	138
XXXI	Sheep Raising	31	4	27
XXXII	Miscellaneous	24	4	20
XXXIII	Nondescript	316	316	—
	Total Crop Farms	12,622	2,042	10,580
	„ Mixed Farms	9,537	1,255	8,282
	„ Live Stock Farms	2,373	433	1,940
	„ Miscellaneous	24	4	20
	„ Nondescript	316	316	—
	GRAND TOTAL	24,872	4,050	20,822

TABLE XX

NUMBER OF SQUATTER CATTLE ON FARMS OF VARIOUS TYPES

Index No.	Type of Farm	Total	Small Farms	Large Farms
	Crop Farms—			
I	Coffee	30,191	2,903	27,288
II	Coffee and Maize	24,697	1,405	23,292
III	Coffee and Pyrethrum	1,708	20	1,688
IV	Coffee and Mixed Field Crops	9,355	1,208	8,147
V	Mixed Field Crops	9,754	4,925	4,829
VI	Pyrethrum	—	—	—
VII	Tea and Mixed Field Crops	64	—	64
VIII	Tea	77	—	77
IX	Maize	4,809	2,218	2,591
X	Wheat	1,735	1,100	635
XI	Coco-nuts	—	—	—
XII	Essential Oils	—	—	—
XIII	Fruit	459	335	124
XIV	Sugar	954	—	954
XV	Sisal	6,442	—	6,442
XVI	Sisal and Coffee	3,597	—	3,597
XVII	Sisal and Maize	1,430	—	1,430
	Mixed Farms—			
XVIII	Coffee and Cattle:			
	A. Dairy	3,181	220	2,961
	B. Non-dairy	3,553	—	3,553
XIX	Coffee, Maize and Cattle:			
	A. Dairy	3,918	—	3,918
	B. Non-dairy	12,650	427	12,223
XX	Coffee, Mixed Field Crops and Cattle:			
	A. Dairy	284	—	284
	B. Non-dairy	5,386	233	5,153
XXI	Maize and Cattle:			
	A. Dairy	300	—	300
	B. Non-dairy	3,381	1,035	2,346
XXII	Wheat and Cattle:			
	A. Dairy	541	541	—
	B. Non-dairy	823	773	50
XXIII	Pyrethrum and Cattle:			
	A. Dairy	3	—	3
	B. Non-dairy	33	33	—
XXIV	Mixed Field Crops and Cattle:			
	A. Dairy	6,915	1,029	5,886
	B. Non-dairy	6,640	1,923	4,717
XXV	Mixed Field Crops, Tea and Cattle:			
	A. Dairy	—	—	—
	B. Non-dairy	—	—	—
XXVI	Sisal, Mixed Field Crops and Cattle:			
	A. Dairy	1,480	—	1,480
	B. Non-dairy	—	—	—
	Live Stock Farms—			
XXVII	Dairy	3,898	697	3,201
XXVIII	Dairy and Sheep	723	—	723
XXIX	Cattle Raising	39	39	—
XXX	Cattle and Sheep Raising	83	—	83
XXXI	Sheep Raising	—	—	—
XXXII	Miscellaneous	—	—	—
XXXIII	Nondescript	1,143	1,143	—
	Total Crop Farms	95,272	14,114	81,158
	„ Mixed Farms	49,088	6,214	42,874
	„ Live Stock Farms	4,743	736	4,007
	„ Miscellaneous	—	—	—
	„ Nondescript	1,143	1,143	—
	GRAND TOTAL	150,246	22,207	128,039

Summary and Conclusion

The particulars given in this analysis serve rather as a source of statistical information purposes than as a succinct formation for reference purposes than as a succinct account of a particular inquiry. It is impossible to attempt much in the way of a summary of the facts brought to light without running the risk of repetition on the one hand or inadequate statement on the other.

One or two broad conclusions may be discussed, however. One is that a fair measure of progress in the direction of mixed farming had been made between 1932 and 1936, the number of "crop" farms and the number of one-crop farms having been reduced. From the fact that 52 per cent of the farms were still classed as "crop" farms, it would seem that there was still a long way to go in the same direction. Some 26 per cent, out of the 52 per cent, however, were devoted exclusively to one plantation crop (coffee, tea, coco-nuts, sisal, sugar, fruit), and the situation of many of these is such that development on mixed farming lines is hardly feasible.

A second conclusion concerns the scale of farming operations. A standard has been taken as differentiating "large" farms from "small" farms, and it has been shown that about one-third of the farms fell into the "small" class. This fact has a social rather than an economic bearing. The optimum size of farm business depends on the scale of income that we think should be regarded as a minimum for a European settler wholly dependent on farming operations. It would appear that the development present on the "small" farms cannot support a standard of living that includes a well-built dwelling, motor car of recent model, club fees, annual holiday at the coast, boarding school education for children, etc. It may be unwise to trust that extraneous sources of income will continue to maintain a standard of living that the farm itself would not provide.

In most lines it is apparent that the bulk of the produce is produced by a relatively small number of farms. This fact has an important bearing on the form that Government assistance should take. Measures that have as their object the raising of the price of the product will benefit relatively few farmers to any appreciable extent. It would appear to be of the first importance to ascertain what are the barriers to extension of operations on so many farms. Only when this is ascertained will it be possible to decide whether consolidation of existing settlement or attraction of new settlement should take precedence.

Certain of the figures indicate that production is relatively less efficient on the "small" farms. The labour equivalents are, generally speaking, much higher on the "small" than on the "large" farms. One striking fact is that, though a total of 179 combine-harvesters was returned in the 1934 Census (the last occasion on which such information was called for), only 12 farms in 1936 returned acreages of wheat of 500 or over, and only 56 returned acreages of 250 or over. The degree of development also, as measured by the ratio between crops and live stock and area occupied, is appreciably greater on the "large" than on the "small" farms.

The comparative degree of development, coupled with the existence of a quarter of a million acres in "nondescript" holdings and some two million acres alienated but not occupied, offers some material of a study of the possibilities of further settlement. The statistics as a whole may help to indicate the point where closer settlement will be possible only with a restriction of the scope of those already on the land.

In the interpretation of the statistics given in this article it is necessary to bear in mind that they relate to the year ending February, 1936. Four years of depression had been experienced, aggravated by local adverse circumstances, such as locust attacks and drought. Prices were only just beginning to show an upward trend. Reserves had been depleted, and the sources of credit had to a large extent dried up. The situation was not such as to encourage the adoption of a forward development policy on the part of farmers. Since that date the position has changed, and it is reasonable to suppose that material changes in farm organization are now in progress. It is hoped that future studies along similar lines will indicate the direction and extent of these changes.

Lining up Tractors and Ploughs

In the "Hints" on this subject printed in the July Journal it was stated that "both tractor tracks should always run on unploughed land and not in the furrow." On this point, Mr. C. B. Tennant, of Kibelewa Estate, Chemelil, has written commenting as follows:—

"I do not think that the position of the tractors to the furrow is fixed in this way. For the tractor to work at maximum efficiency the line of draught of the plough should pass through the centre point of the wheel or track axle of the tractor. As there is side thrust on the plough away from the furrow, its centre will not follow the centre of the tractor but a certain distance more to the land side. The furrow fixes the position of the plough, and the tractor will be a certain amount more towards the furrow. Unless the width of the tractor wheels or tracks is less than the cut of the plough, the furrow wheel of the tractor must run beyond the furrow margin."

The point has been referred to the author of the original "Hints", who writes:—

"In the first place, most tractors are equipped with a swinging drawbar, usually working between two parallel horizontal guides. These guides are usually semi-circular in shape, and have a series of holes with a corresponding hole in the drawbar. The idea is to enable an implement to be off-set behind the tractor by fixing the drawbar through a suitable hole in the guide. This is common practice in both road construction and ploughing operations.

"In ploughing, the track must not be run in the furrow, as one side of the tractor would then be lower than the other, throwing the weight of the tractor to the lower side. Although tractors are made to withstanding the strain caused by normal undulations in the field, it must not be forgotten that in working the tractor with one track in the furrow the strain and weight are *always* to one side. Assuming that the tractor is used for ploughing and harrowing only, it means that approximately 75 per cent of its life is used up in ploughing and only 25 per cent in harrowing. Any good make of tractor is considered to have a life of not less than 10,000 working hours, which means that for 7,500 hours it will be working with one track lower than the other, and the strain is bound to cause mechanical trouble.

"If we accept this argument, then to counteract these effects we must use the swinging drawbar provided, and off-set the plough. Off-setting does not mean that the plough will not run straight; with correct setting it will run just as straight as if it was connected centrally on the tractor."

Experimental Breeding of Fibre Agaves in East Africa

Part II—The Progress of Breeding at Amani

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MATERIAL

I do not propose to describe in detail all the promising species of Agave but only to indicate the outstanding characters of the more advanced material in our collection. Where figures are given they merely indicate trends in development, not absolute values, as environment has a considerable modifying effect. At the present time there is insufficient material to lay down formal experiments to compare the development and yield of the various species. An experiment is in progress at the Sisal Experiment Station, Ngomeni, to compare Sisal, Blue Sisal, Cantala and Henequen. [2]

Agave angustifolia Haw.—This species is outstanding for rapidity of development and total leaf production. The plants under observation at Amani put on new leaf at approximately three times the rate of *A.sisalana*. The leaf is short, light and contains only a small weight of fibre; the proportion of fibre to leaf weight is, however, about 3 to 3.5 per cent. The leaf margin is spiny, the fibre very fine. Plants allowed to develop naturally pole at about the same age as *A. sisalana* under similar conditions. The maximum number of leaves produced by a plant of this species during its productive life is 510, compared with a maximum for sisal of 230 under similar conditions. It is a sexually fertile species.

A. amaniensis Trelease and Nowell (Blue Sisal).—The origin of this species is obscure. It was found growing under heavy shade in the Amani plantations. [3] Producing a long, heavy leaf with a non-spiny margin and containing a very fine fibre, this species is most promising. It is also sexually fertile and a large number of seedlings have already been raised. A plant of this species, 2½ years old, grown at the Sisal Experiment Station, Ngomeni, is illustrated in Fig. 1.

A. cantala Roxbg.—This species is well known in the East but not cultivated commercially in East Africa, although it has been introduced. The leaf is long but not heavy, the leaf margins armed with very strong sharp spines and the fibre very fine and strong. The yield appears to be low. Dr. Hindorf informs me that this species was introduced in 1911 from Java and was planted on Mwera Estate and Gomba Estate. I have had several opportunities of studying the species at Mwera, and am indebted to Messrs. Amboni Estates Ltd. for my material. This species appears to be completely female sterile, but a small proportion of the pollen is fertile.

A. fourcroydes Lemaire (The Henequen of Central America).—This is another species not cultivated in East Africa, although specimens are being grown by H. Tanner, Esq., at Amboni, Tanga. The plant produces a long heavy leaf, borne on a marked trunk. The leaf margins are strongly spiny; the fibre is described as coarse, but under East African conditions is very similar to sisal. Development is rather slower than that of sisal. This species fruits sparingly and has been used as the female parent in crosses with sisal in Porto Rico. [8]

A. sisalana Perrine needs no description. Fruits and seed have been obtained from a number of districts in East Africa, always from cut poles. Repeated efforts

to secure fruiting in Amani and on the neighbouring sisal plantations by cutting back the poles have not met with any success, but the pollen of this species can be used in making crosses.

Other species deserving passing mention, although their potentialities have not yet been thoroughly explored, are: *A. nirvana* and *A. fortuna,* two forms with spineless margins received from La Mortola under these unpublished names; *A. decipiens* Baker, the false sisal of Florida; *A. miradorensis* Jacobi, *A. Lespinassei* Trelease, *A. Zapupe* Trelease. The last two species are cultivated for fibre in Mexico [7], have spiny leaf margins and are reputed to produce a fine fibre. All these species fall into the Rigidae group of Euagave.

The sisal-grower would like an improvement in the proportion of fibre to leaf weight, but there is little indication that this can be obtained with any of the species that have been studied. In most species of Agave the proportion is about the same as that for sisal.

The first seedlings of *A. sisalana* were raised in 1929 from seed received from the Kenya Sisal Growers' Association. Messrs. Amboni Estates Ltd. and Messrs. Bird & Co. kindly set aside areas of land at Amboni and Magunga, Korogwe, on which to grow these seedlings. The seedlings were transplanted in 1931, when some of the plants were rather large, and there were many casualties. One hundred representative plants were retained at

Fig 1. *A. amaniensis* 2½ years old. Grown at the Sisal Experiment Station, Ngomeni.

Amani. A second consignment of seed was received from J. McRae, Esq., Longonot, in 1933, and nine thousand seedlings raised from this seed were planted at Sigi, Amani, in 1934. Fig. 2 shows some of these seedlings at two and a half years old; the variability in vegetative characters is apparent.

Among the 14,000 seedlings that have been raised there are no plants completely devoid of spines on the leaf margin. There is a very wide range of variation in vegetative characters and also in size, from the giant to the dwarf.

Fig 2. Seedlings of *A. sisalana*, 2½ years old. Sigi, Amani.

Six plants have been selected from the Magunga plot for further trial and several more from the Amani plot. The young plants from the second batch of seed are now three years old and ready for cutting for the first time. It is impossible, with the present staff, to keep continuous records on the development of all the seedlings raised; so that in the Sigi plot three blocks of two hundred plants each have been marked out and records maintained on these. Other outstanding plants on other parts of this area are also examined periodically.

Among the seedlings that have reached the poling stage there are no outstandingly productive forms. The maximum leaf production shown by any individual during its life is 331. This figure is not greatly in excess of that found for vegetatively propagated sisal, which ranges between 200 and 300 leaves. As I have indicated earlier in this paper, development may be profoundly influenced by environment, and as the observations are based on the behaviour of single plants, each unique, there is a great deal of room for error. A further trial of the vegetatively propagated offspring of the most promising of these seedlings is projected in co-operation with the Sisal Experiment Station, Ngomeni. Cytological observations have shown that *A. sisalana* is a pentaploid, i.e. with five times the basic chromosome number x (=30) for the genus. The meiotic divisions, cell divisions

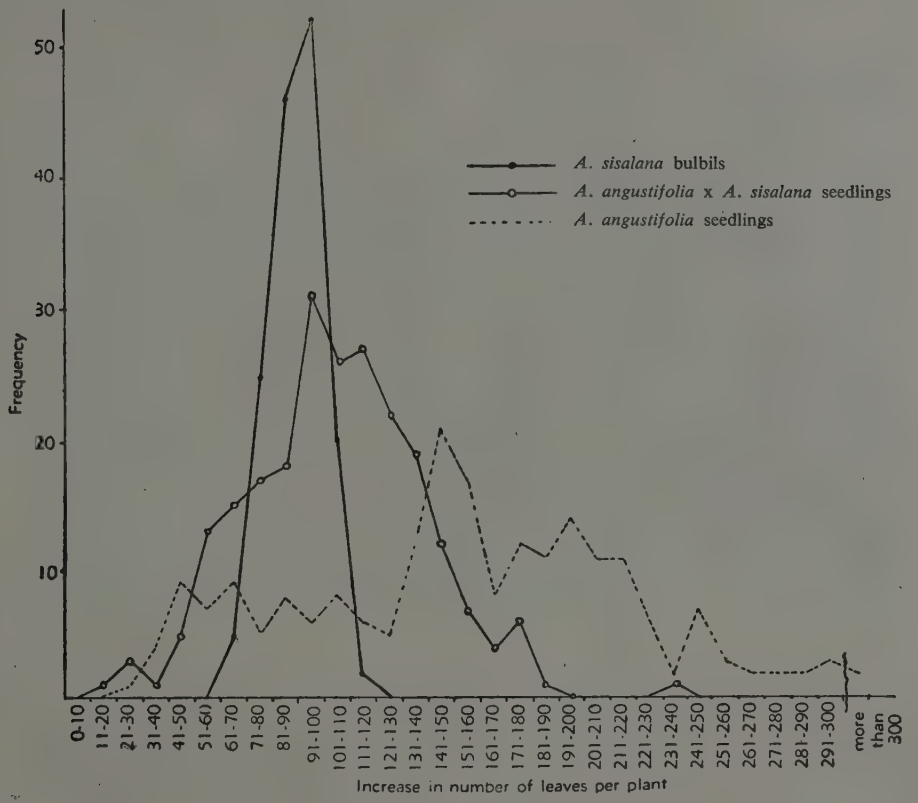


FIG 3. Variation in increase in leaf number from April 1934 to July 1936 for three families of Agave

that are concerned in the formation of the reproductive cells (gametes), are not regular; as a result, the gametes contain a varying number of chromosomes, and consequently varying genetical potentialities. This is the fundamental reason for the very wide variation in the characters of the seedlings.

Seedlings of *A. angustifolia,* a diploid species (2x), show a wide variation in the rate and in the total quantity of leaf produced, but not so wide in form as *sisalana* seedlings; *angustifolia* seedlings could not be mistaken for any other species. The range of variation in leaf production among *A. sisalana* bulbils compared with that found among seedlings of *A. angustifolia* and of the hybrid *A. angustifolia* × *A. sisalana* is illustrated graphically in Fig. 3. The figure shows, in the form of a frequency polygon, the range of variation in increase in leaf number per plant over the period April, 1934, to July, 1936. The concentration of the sisal group in the region 56 to 116 leaves per plant compares with the wide range 16 to 236 for the hybrid seedlings and 26 to over 300 in the same period for the *angustifolia* seedlings.

All *angustifolia* seedlings have spiny leaf margins and the leaf is very short; at six and a half years old the average bud length, reflecting leaf length, is only 38.6 cm. One outstanding individual plant in this family, six years old from planting of the seed, has produced 600 leaves and is not yet poling.

this family are illustrated in Fig. 4. The range of leaf length at the first cut is shown in Fig. 5, a histogram of the frequencies in the varied leaf length categories. The position of the mean leaf length for the *selfed* seedlings of the female parent, *A. angustifolia,* is indicated by an arrow. The hybrids show a much greater leaf length than the selfed seed-

TABLE 1

SUMMARY OF RESULTS OF CROSSING AND SELFING AGAVE SPECIES

Female Parent	Male Parent	Date of Cross	No. of Flowers Pollinated	No. of Fruit Obtained	No. of Seed Obtained	No. of Plants Raised	Proportion of Plants with Non-spiny Margin
							Per cent
1. *A. angustifolia* (2x) ..	*A. sisalana* (5x) ..	1931	—	—	—	235	0
2. *A. angustifolia* (2x) ..	*A. ingens* var *picta* (4x) ..	1932	—	—	—	213	0
3. *A. ingens* var. *picta* (4x)	*A. angustifolia* (2x)	1932	—	16	—	85	0
4. *A. amaniensis* (2x) ..	*A. angustifolia* var *marginata* (2x) ..	1935	—	12	1,364	172	12·4
5. *A. angustifolia* var. *marginata* (2x) ..	*A. amaniensis* (2x)	1935	—	69	ca.15,500	3,326	16·6
6. *A. amaniensis* (2x) ..	*A. cantala* (3x) ..	1935	1,200	—	—	—	—
7. *A. amaniensis* (2x) ..	*A. sisalana* (5x) ..	1935	1,099	232	7,545	379	0
8. *A. amaniensis* (2x) ..	*A. cantala* (3x) ..	1937	—	7	185	—	—
9. *A. angustifolia* (2x) ..	*A. cantala* (3x) ..	1937	362	21	460	—	—
10. *A. angustifolia* (2x) ..	*A. angustifolia* × *A. sisalana* F1, No. 56 (?x) ..	1937	45	12	246	—	—
11. *A. angustifolia* (2x) ..	*A. angustifolia* × *A. sisalana* No. 78 (?x)	1937	113	5	25	—	—
12. *A. angustifolia* (2x) ..	*A. Lespinassei* (?) (2x)	1937	59	56	ca.17,000	—	—
13. *A. amaniensis* (2x) ..	*A. Lespinassei* (2x)	1937	102	69	—	—	—
SELFINGS							
1. *A. angustifolia* ..	.. .. ..	1931	—	—	—	236	0
2. *A. amaniensis*	.. .. ..	1934	—	—	—	939	58·3
3. *A. ingens* var. *picta* ..	.. .. ..	1932	—	—	—	15	0

Other seedlings, still young, having been planted at Ngomeni in 1936, are families of *A. fortuna* and *A. amaniensis.* Both these species show segregation of forms with spiny and with non-spiny leaf margins.

HYBRIDS

The results of interspecific crossing are summarized in Table 1.

The first generation hybrids from cross (1) were planted in the field in 1932. There is a wide range of variation in both the rate and total leaf production and in leaf length, weight and form. A few plants of

lings. Several plants were ready to cut in 1935, but cutting was delayed until my return from leave in 1936. The histogram, Fig. 6, shows the variation in yield of leaf; the greater portion of the individuals fall into the low yielding categories. There are nine plants giving a yield of 100 lb. of leaf or over for the first cut. *A. sisalana* bulbils, on an adjoining plot under similar conditions, gave an average yield of about 70 lb. of leaf per plant (indicated by an arrow in Fig. 6) for the first cut, taken when the plants were three and a half years old.

FIG 4. Hybrid plants from the cross *A. angustifolia* × *A. sisalana*. 4 years old. Amani

Many of the plants of this hybrid have a well-developed trunk and all have marginal spines. Each plant is unique, and it is impossible at this stage to determine the effects environment has had on individual development; this can only be determined after further trial.

The hybrids (2) and (3) have little economic importance but are interesting genetically. *A. ingens* var. *picta* is a large ornamental Agave belonging to the Americanae group. Family (2) has a more erect habit of growth and bigger leaves than (3), which reproduces the out-curving leaf habit of the *ingens* parent. These hybrids have suffered from weevil attack.

Crosses (4) and (5) are still young. Planted out at Ngomeni in 1936, they are making good progress, and early observations indicate that the rapid growth habit of *angustifolia* is dominant in the hybrid. A proportion of these hybrids are devoid of marginal spines. One plant of this cross is illustrated in Fig. 7.

A comparison of the rapidity in leaf production between these hybrids and the seedlings of *A. amaniensis* and *A. fortuna* is made in Table 2.

TABLE 2

Comparison of the Mean Leaf Increase per Plant for Seedling and Hybrid Families at Ngomeni for the Period November, 1936, to March, 1937

Family	N.	Mean Increase per Plant	s.	V.	Mean Length of Bud
				%	*cms.*
A. amaniensis	880	6·54	3·07	47·0	41·67
A. amaniensis × *A. angustifolia* (4) ..	173	18·95	6·29	33·2	29·50
A. angustifolia × *A. amaniensis* (5)..	1,036	18·21	7·21	39·6	26·68
A. fortuna ..	1,055	9·78	5·49	56·0	23·87

In April, 1937, a further five hundred seedlings of *A. amaniensis* were planted at Ngomeni.

FIG. 5. Histogram showing the variation in leaf length in the hybrid *A. angustifolia* × *A. sisalana*. First cut 1936.

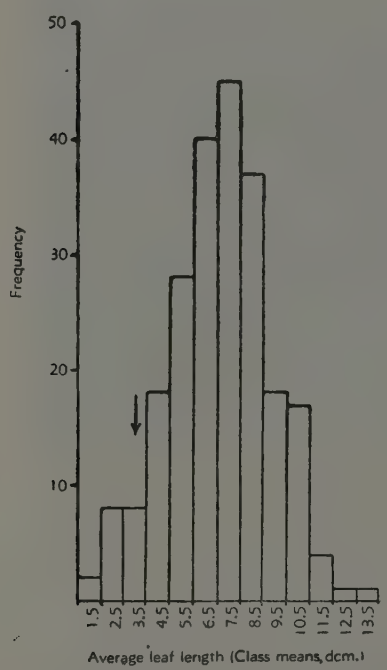
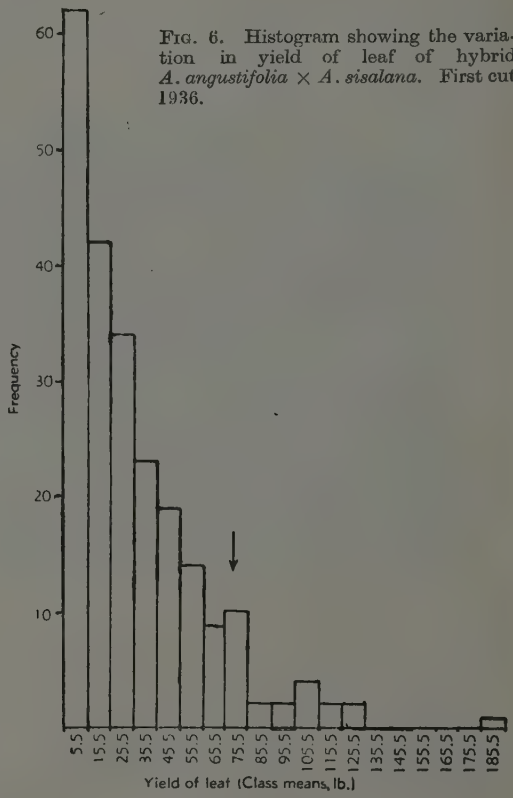


FIG. 6. Histogram showing the variation in yield of leaf of hybrid *A. angustifolia* × *A. sisalana*. First cut 1936.



Plants of cross (7) made rather slow growth in the early stages and were not planted out until April, 1937. A wide range of variation in vegetative characters is already visible.

The fruits of crosses (8) to (13) have only recently been harvested and it is too early to comment further on them.

ANATOMY OF THE LEAF AND FIBRE TECHNOLOGY

As I have mentioned in Part I, the anatomy of the leaf and distribution of the fibres in the leaf tissue are described by Nutman [4 and 5] and Tobler [6]. An examination of cross-sections of an Agave leaf gives some idea of the fibre qualities of a plant. The methods of testing prepared samples of fibre—Nutman [4]—are rather slow and laborious, and since no other satisfactory methods have yet been devised most of the work that has been done on seedlings and hybrids in an endeavour to assess their commercial value has been confined to an examination of the fibre in leaf sections. Some idea of the variation in the sectional areas of the fibres in the hybrid *A. angustifolia* × *A. sisalana* can be gained from Figs. 8 to 11, compared with the two parents, Figs. 12 and 13. All are drawn to the same scale, and represent the fibres lying close to the upper and lower surfaces of the leaf respectively. It is interesting to note that

those near to the lower surface are in general much coarser than those near to the upper surface.

The results of fibre tests on prepared samples of fibre from seedlings of *A. sisalana* are summarized in Table 3. The samples from the Amani seedlings were taken from leaf cut at four years after planting in the field, and those from Magunga plants after three and a half years in the field.

In a recent article on fibre testing, Nutman [4] quotes the weight in milligrams per 10 cm. length, called "F", for fineness. As the test lengths of fibre are representative samples of the bulk to be assessed, I think that the metric number is possibly a better expression for fineness of a bulk of fibre, and as this term is in general use for expressing this characteristic, cf. Barker [1], I propose to retain it. The difference only lies in the manner of ex-

FIG 7. A plant of the cross *A. amaniensis* × *A. angustifolia*. 1½ years old; grown at Ngomeni.

The metric number is the length, in kilometres, of single fibre weighing one kilogram. The breaking length is that length of fibre, again in kilometres, which if suspended at one end would break under its own weight. Thus the greater the metric number the finer the fibre, and the greater the breaking length the stronger the fibre.

pression as the metric number is directly derived from Nutman's "F".

It will be seen that eight of the Amani samples are finer than the control sample of sisal, but only three are finer than the average for estate samples. Five of the seven Magunga samples are finer than sisal, but only two of the whole series have a greater breaking length. Only one sample, Magunga 1, compares at all

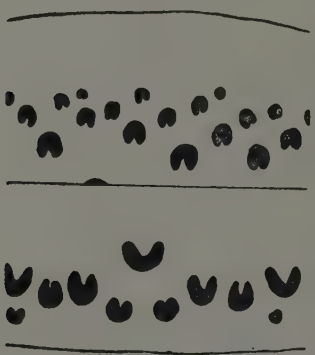


FIG. 8

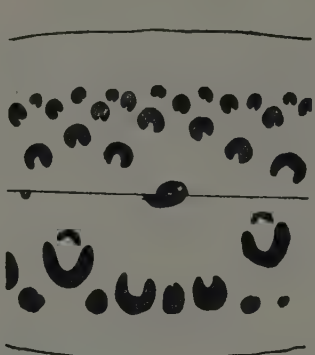


FIG. 9

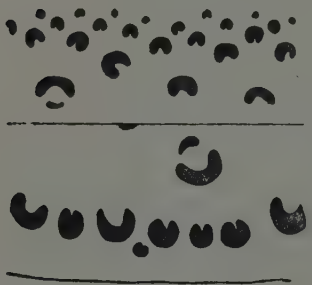


FIG. 10

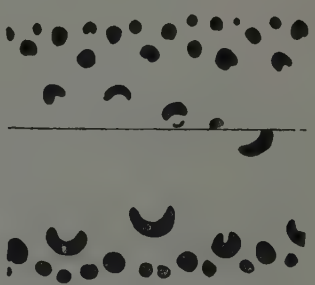


FIG. 11

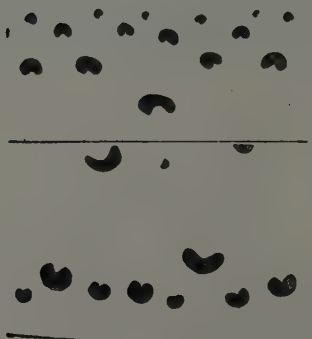


FIG. 12

A. angustifolia

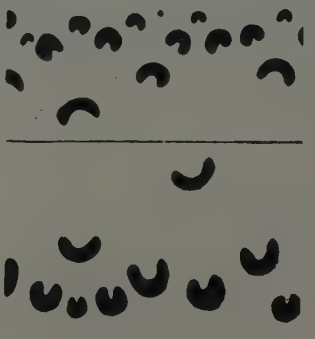


FIG. 13

A. sisalana

favourably with *A. cantala* for fineness and this sample is weaker. The two samples of *amaniensis* fibre show rather wide differences in both fineness and strength. Only three seedling samples compare with the poorer sample for fineness, Amani No. 48 and Magunga Nos. 1 and 2. No. 48 compares favourably in strength.

TABLE 3

Fibre Characteristics of some Seedlings of *A. sisalana* Compared with the Parent and Other Species of Agave

	Metric Number	Breaking Length
A. sisalana (A) ..	25·25	42·72
A. sisalana (B) ..	29·58	43·77
SEEDLINGS		
AMANI—		
No. 48	38·46	40·42
„ 11	33·11	35·66
„ 40	31·85	35·19
„ 46	29·50	44·31
„ 41	29·39	34·19
„ 33	29·24	36·52
„ 47	26·38	33·01
„ 24	25·44	31·73
„ 13	25·12	32·81
„ 12	24·21	43·03
„ 7	23·92	35·86
„ 8	22·37	37·73
„ 9	21·55	33·81
„ 14	20·45	32·15
„ 15	15·70	28·92
MAGUNGA—		
No. 1	47·5	31·9
„ 2	39·9	38·6
„ 7	37·6	37·2
„ 4	35·3	39·6
„ 6	31·4	40·8
„ 5	29·3	30·1
„ 3	27·2	35·6
A. cantala	43·67	35·1
A. amaniensis (1) ..	38·17	39·1
A. amaniensis (2) ..	45·45	45·3

NOTE.—*A. sisalana* (A) control sample from same plots as seedlings. (B) Average of 15 estate samples. *A. amaniensis* (1) second cut, (2) third cut. *A. cantala*, a sample from Java.

DISCUSSION

The results that have been obtained from a study of seedling progeny of Agave species indicate that there is a wide field available for selection of types that are superior to sisal in one or more characters. The very extensive range of forms observed in the progeny of the polyploid species indicates a hybrid origin of the parent form, and none of the seedling progeny of these forms shows a combination of all the desirable characters. It is impossible to predict the results of further breeding work with these forms, should they prove sexually fertile, and any future work will be strictly empirical. A further study of their fibre characteristics may show that the economic value of the product counterbalances the disadvantages on the cultural side. Once a desirable form is obtained it can be reproduced true to type fairly rapidly by vegetative means.

The work with the diploid forms has not yet reached the stage when any definite statements can be made about the future. The ease with which some of these species in the Rigidae group can be crossed indicates a fairly close affinity, and they may prove fertile in the first hybrid generations. If so, a wide field for further work lies open. *A. amaniensis* and *A. angustifolia,* to mention but two species, provide a valuable starting point in this way. The first generation of crosses between these two species, in the early stages of development, has been shown to hold great promise. If these hybrids can be carried to the second and further generations, the prospect is still brighter.

Hybrids between diploid and polyploid species provide a wide range of forms, but it is again doubtful if any of the first generation plants will prove fertile; so that unless valuable forms appear in this

generation this line of attack is abortive. The necessity of raising large families is obvious.

The scope for improvement in quality of the fibre has not been defined. The only guidance in determining desirable qualities is that quoted in the text. Problems connected with quality in agricultural products have repeatedly proved to be the most difficult to solve and without close co-operation between the producer, the consumer and the experimentalist it is impossible to formulate a sound policy to be followed in progressive work. The consumer of fibres has usually little or no intimate knowledge of the physical qualities of his raw material. He can only form a general opinion of the primary product and give a considered opinion of the finished product. The processes of manufacture are generally such that very small quantities of fibre cannot be utilized, and so it is very difficult to get a definite opinion of the potentialities of a new fibre. It is obviously impossible in the early stages of breeding work to produce, in quantity, all the fibres it is desirable to test, and under present conditions this is a limiting factor in the work that can be undertaken.

Adequate methods of testing strength and fineness of fibre samples on a small scale have been devised, but the interpretation of these results on a commercial basis is not yet possible.

It is obvious that investigations on the relations between the physical characters of the fibre and manufacturing requirements will have to be undertaken and the active co-operation of the manufacturers enlisted before much further progress can be made in the improvement in the quality of fibre-producing Agaves.

SUMMARY

Seedling progeny of the species of Agave so far studied show a wide range of variation in rapidity of development, leaf production, yield and the qualities of the fibre.

The most promising lines for breeding research are provided by a study of the inbred seedlings and interspecific crosses of the diploid species, although there is a wide field for selection among the sexually propagated offspring of the polyploids.

Fibre qualities of sisal seedlings and the productivity of certain hybrids are reported.

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Compost on a Mixed Farm in Kenya

By J. E. A. WOLRYCHE-WHITMORE, *Rongai, Kenya Colony.*

There seems to be a common belief amongst farmers that composting is not worth the trouble, and that it is expensive and complicated. Several years of experience of composting at Rongai have satisfied me that the cost can be kept quite low and that the results are very encouraging.

Composting on this farm at Rongai was started some four years ago, and was intended to follow somewhat the Indore lines, but with a less elaborate system of measurements to suit the type of labour employed. Some 300 tons were produced the first year, and during the last twelve months we have made over 1,200, and we hope to work up to 2,000 tons. Two farms of about 2,700 acres are worked as one, and have 1,100 acres under main crops and some 250 under a weed fallow.

The first compost made was at the milking shed and one ox *boma,* both of which are situated some distance from water and the nearest fields, and it was soon apparent that much extra labour was wanted to get water and roughage to the compost yards. We have gradually been altering our methods, and now are trying to arrange that all our fields have water near them, and we are making most of the compost within 60 yards of the edge of the field. We are gradually broad-base terracing the whole farm, and we collect the water off the terraces into small dams dug with dam scoops. These dams should, where possible, be a minimum of 8 feet deep, so as to provide water through the dry weather when the compost-making is in full swing. Depth rather than area should be the aim.

We have on this farm about 190 working oxen, about 70 cows in milk, and a dry and young herd of 100. The manure from the cows is only available for the time when they are waiting to be milked, but the rest of the cattle are in the yards about ten hours out of the twenty-four. We employ a permanent gang consisting of a cheap head boy and eight boys whose sole job it is to keep the cattle supplied with bedding, to remove it and make and turn the compost. In addition, for at least six months of the year, we have two half teams of oxen, with four boys each, engaged on bringing the roughage to the yards.

The roughage consists of any form of straw left behind the combine, maize stalks, maize cobs, grass, Napier grass, weeds, Mexican marigold; in fact, anything we can get hold of. We are now making compost at six points on the farm, and as the land gets terraced hope to have water at about 550-yard intervals alongside the fields. The general lay-out will be to site the dams just far enough from the edge of the field to allow for a dump of roughage next to the edge, a cattle *boma* about 15 to 20 yards square, and a compost yard about 15 yards wide between the *boma* and the dam.

Loading straw and maize stalks on to wagons is slow work, and we are now gradually getting away from them and using skids and sweeps, both of which save time and labour. Where the land is fairly smooth, a skid measuring 18 ft. by 14 ft., made of gum poles, will be found much quicker than a wagon. The frame is of four poles lengthways and five across, bolted at all joints with half-inch bolts and further stiffened with two diagonal stays at each end. A few wires may be stapled on top if the roughage is rather short. Two ropes, about 45 feet long and about one inch diameter, are attached to

the front end and allowed to trail over the frame, being kept apart by a pole about 7 feet wide at the rear end. From half a team to a full team are required to pull the skid, according to the weather and the roughness of the ground.

The skid is dragged alongside the windrows and boys throw the roughage on to it. When the load is completed and drawn to the dump the oxen are unhitched from the front and attached to the two ropes, which are now brought from the back over the top of load. The load is rolled off complete as the oxen go forward. The oxen are again unhitched and can draw the skid backwards from the dump. When making hay, a skid can bring up 12 to 15 tons per day with a haul of up to 300 yards.

When the ground is more uneven and terraces have to be crossed a sweep on the lines of the tractor hay sweep employed in England can be easily made on the farm, and we have had one of these working for two seasons with oxen.

A frame is made, preferably of sawn timber, about 4 in. x 4 in., but gum poles will do; length, 4 ft., width, 12 ft., bolted at the corners. An upright, about 3 ft. high, is mortised into the centre of the two 4 ft. sides, and is stayed by wires front and back. A top bar connects these two uprights. Two wheels, about 24 in. diameter, are mounted towards the outside of the frame, one on each side on short axles, so that the frame balances on them. Under this frame, and at about 15 in. intervals across it, are bolted the long prongs for the sweep. These are of gum poles, 10 ft. long about 3½ in. diameter, tapering to 2 in. and shaped to a point. At the rear of the frame is bolted a stout pole, about 14 ft. long over all, which is used to help steer the machine. The balance should be arranged so that the sweep points rest lightly on the ground and can be raised easily by depressing the steering pole.

Two long chains are attached, one on each side of the short sides of the frame; they should be sufficiently long to allow the oxen to keep well clear of the points. Four oxen are attached on each side, and are led on each side of the windrow, the sweep picking up the windrow as it goes along.

The boys who lead the oxen have to take care that both lots go the same pace. A boy at the back holds the pole and can direct the machine to a certain extent. It takes the boys some time to get into the way of using the skid, but once they do so they can move a lot of roughage in the day. We have found it quite economical up to 500 yards haul. Occasionally a point is broken, and it is as well to have a spare ready drilled, as this can be put in at once by removing the two frame bolts.

Our methods of making compost are fairly primitive, but the result after three or four months is a very serviceable article, though not so finely broken down as the Indore compost.

The yards have about six inches to a foot of roughage thrown in to them, and the cattle break this down for a few days, when possibly another layer is added and broken down. This is then carried out on stretchers to the pits or heaps, where it is loosened and spread in layers about 6 in. deep by 15 ft. by 15 ft. Wood ashes and some of the earth from under the cattle are added, together with a little compost from an earlier heap. We are now also using either bone meal or Seychelles guano at the rate of about 15 lb. per ton of material, but a lot of our compost has not had this.

The layer of material is now well watered, the water being thrown on with a sweep of a *kerai* (mason's pan), and further layers are added up to about 4 ft.

Each heap has a numbered peg and is recorded in a book kept by the head boy, under the headings of the date of making the heap and first, second and third turnings, and date of taking to the field. It is thus easy to keep track of each heap. Under favourable conditions, the gang of boys can make one new heap and turn one or two more each day. This of course depends on how packed and wet the material in the yard is. As far as possible we try to mix the various kinds of roughage, but quite often have only maize stalks.

When it comes to spreading on the field we use an American manure-spreading wagon, which we find very much more satisfactory than spreading from heaps dumped in the field. We have had one wagon in use for ten years. They cost about £50, but are very well worth it, as the manure is spread quicker and more evenly, whilst the loading is much faster than when using a cart or wagon. Our wagon takes about 1½ tons, and eight trips per day to a distance of a mile is not out of the way. The rate of application can be altered in a moment by a lever.

From ordinary farm estimates it appears that one ton of compost (without phosphates) will give an extra yield approximating to one bag of maize or its equivalent in other crops. This is being borne out by the experiments on the Government plots on this farm, where applications of compost in 1935 gave the following results:—[1]

	Yield in bags per acre.	*Per cent.*
Control	13.3	100
3 tons	16.6	124.7
6 tons	17.8	133.7
8½ tons	18.9	142.1

In 1936 the experiment was replanted without any further addition of compost, and results were as follows:—

	Yield in bags per acre.	*Per cent.*
Control	13.49	100
3 tons	13.84	102.6
6 tons	15.03	111.4
8½ tons	16.71	123.8

As our compost is costing us well under Sh. 1/50 per ton, it will be seen to be a very profitable investment; this, of course, does not take into account the added phosphates. The usual objection to farmyard manure, that it brings in weeds and couch, does not apply to compost, as the high temperatures reached during the fermenting process effectively destroy weed seeds and also Smut and Pink Ear Rot spores.

[1] *East African Agricultural Journal*, Vol. II, No. 4, p. 255, 1937.

Breaking in Young Oxen to the Yoke

In the Journal dated July, 1937, we reprinted from the *Rhodesia Agricultural Journal* an article with the above title by a local farmer, in which he described a method of breaking young oxen. Evidence has now come to hand that the method cannot be utilized in Kenya without the greatest care and probably only with substantial modification. Mr. G. F. L. Mohr, of Kanga Farm, Rongai, has been good enough to communicate his experience of the method, which can only be described as disastrous. He writes as follows:—

"I first bought 2½ in. piping as recommended in the article, but found that the two lengths of 5 ft. 6 in. piping plus the four ⅞ in. bolts made the thing so heavy that the bullocks undoubtedly in no time would have no skin left on their necks.

"I then made the double yoke of olive wood instead of piping, but otherwise exactly according to instructions in the article.

"I put the yoke on one young bullock and one heavy trained elderly beast.

"They went off all right, milling round. But suddenly the young ox jumped, turned round in the air and fell down, breaking his neck. The trained ox also got his neck twisted, so that I had to shoot him.

"Possibly this outfit might work all right with quiet, grade oxen. But for strong native bullocks my experience proves it to be dangerous. In any case, I believe that the double yoke should not be made 5 ft. 6 in. long. If the yoke is made considerably shorter, so that the bullocks when inspanned come closer to each other, it is possible that they would not be able to turn round as mentioned above."

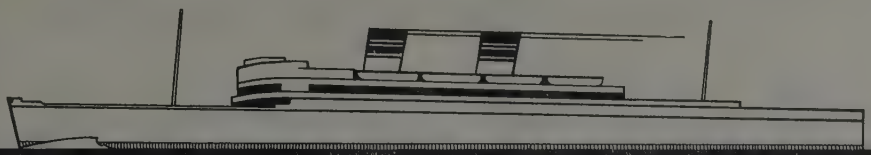
An Adjustable Separator Mounting for Portable Dairy Unit

Mr. A. F. Dudgeon, of Rongai, Kenya Colony, writes:—

"With reference to the article which Mr. Hill wrote in your November issue about an adjustable separator mounting, which I devised for use in a portable dairy unit, he has missed one very important point.

"This mounting is, of course, no good unless it is absolutely rigid, and in order to effect this and to clamp the triangle on to the bench, a three-quarter inch bolt goes through the centre of the bar in the middle and through a hole in the bench, and is tightened up underneath after the mounting has been levelled with the corner screws.

"The bench should be made of 1½ in. planks and should be covered with heavy gauge flat iron, such as $\frac{1}{16}$ in. steel plate, otherwise the ends of the levelling screws will wear holes in it."



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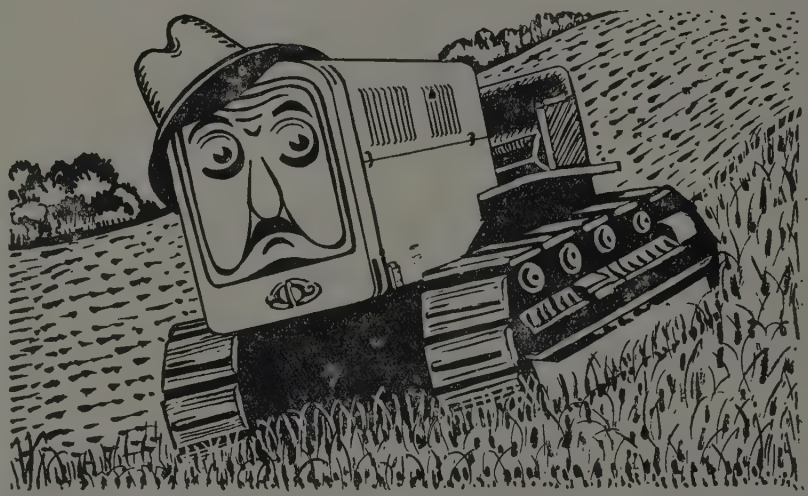

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The Musoma Ghee Industry

By M. H. FRENCH, *M.A. Ph.D., Biochemist, Veterinary Department, Tanganyika Territory.*

In the hot and semi-arid regions of the world not only does the yield of milk vary with the seasons but also it is impossible for primitive people to store milk or butter for use during the dry periods of the year. The inhabitants of hot countries were forced to evolve a method of storing butter fat, and the process developed in India has since spread to other tropical areas. The original Hindustani word for the butter fat so prepared was *ghi* and this term, written as "ghee", has been retained by most workers on this subject.

2. The principle underlying the production of ghee is the preparation, in the solid form, of milk fat free from water, proteins and salts. Variations in the details of preparation and particularly in cleanliness cause ghee to vary enormously from a dirty oily fat, possessing an offensive smell, to an attractive yellow solid. The former quality is typical of the article produced by natives of this Territory for their own use, whilst the good quality article is representative of the product of the Government supervised factories. In Tanganyika the term "Clarified Butter" has been given to the Government supervised article, whilst all native-made butter fat is called "ghee", whether it is made by improved methods or under the old insanitary conditions.

3. The Musoma ghee industry as outlined below illustrates the steps taken by the Veterinary Department to effect a larger production of a better quality article. It indicates the policy of the department towards the large stockowners, namely that (i) the production of ghee can afford a means of obtaining cash in areas devoted to livestock and unsuited to crops, and (ii) these cattle owners may be educated gradually to realize the economic advantage of possessing a few good milking cows instead of a larger number of half-starved poor-yielding animals. The Musoma conditions are well suited to the production of ghee and as a result production there much exceeds that from any other district. Musoma ghee is now well-known commercially, finds a ready market and commands a good price. Nevertheless, it will be seen that there is further room for improvement, even though figures for the sales of ghee show that an improvement in quality has recently taken place. This has been particularly apparent since the introduction of the direct cream-to-ghee method of production.

MUSOMA CONDITIONS

The Musoma district is situated on the east side of Lake Victoria and comprises an area of some 6,200 square miles stretching up to the Kenya border. Five main rivers drain the country from the east into Lake Victoria, but only the largest, the Mara, flows continuously throughout the year. All the other watercourses dry up for varying periods. The altitude of the different parts of the district varies from about 3,700 feet at the Lake shore to 6,000 feet at Tagari, the highest point. As a result it is not possible to indicate any average climatic conditions. The rainfall on the Lake shore averages 30 inches yearly, but varies over the district according to altitude. Most of the rain falls between February and the end of May, but it is doubtful if any part of the district is completely without rain during any month of the year.

The Musoma district is sub-divided into two administrative divisions by the Mara River, which forms a suitable boundary for topographic, climatic, and geological as well as political reasons. The North Mara district generally lies at a higher altitude than South Mara, and as a result the North Mara mountain grassland areas receive a better distributed and probably greater rainfall than the grazing areas of South Mara. The rainfall and its distribution govern the grazing conditions, so that North Mara has an advantage over South Mara for raising cattle and producing milk.

The Musoma district is also divided into cattle and non-cattle areas by the presence of tsetse flies. The greatest concentrations of these flies are in the north, west and south-east portions of the district. The total cattle population of the district is approximately 350,000, but its density varies very considerably, the chief factors being the presence of tsetse flies, the incidence of East Coast Fever, and the vicinity of adequate water supplies and grazing land.

As rainfall is the main factor governing the grazing conditions of the district, it also determines the output of milk and therefore the yield of ghee. Ghee is made in both North and South Mara, but by far the greater proportion of the total output comes from North Mara. There the abundance of grazing all the year round results in an almost steady output of ghee, whereas a seasonal variation is to be observed in the output from South Mara. The Musoma district is thus well suited to the development of a large and prosperous ghee industry.

The natives of the Musoma district were well known in the past for their fierce and war-like tendencies, and their inability to resist the temptations of stock-thieving. The civilizing influence of administration and education has checked stock-thieving and consequently has toned down the belligerent natures of the natives. Through contact with civilization, aided by the recent economic depression and the development of the Musoma gold-mining activities, the Musoma native is fast realizing the economic significance of wealth in the form of money instead of in possessions.

The production of ghee is essentially a cash producing enterprise. When and where agricultural rather than pastoral habits are followed, cash crops such as cotton, ground nuts, and sesame are grown and ghee production becomes of little or no importance. When considering the future of the ghee industry it is necessary to bear in mind the fact that it is the need for cash and not the wish to market a surplus commodity (milk and butter fat) that will determine the output of ghee. The pastoralists who require cash have four alternative methods of obtaining it. They sell some of their cattle, or make ghee, or else they are forced to turn agriculturalists or to seek employment. The true pastoral natives hesitate to adopt the last two alternatives, and much prefer to obtain the necessary cash by the sale of an animal or its products. Therefore the lower the price of stock the greater the tendency for pastoral natives to sell milk or cream for ghee production.

Review of the Development of the Musoma Ghee Industry

Ghee has been made in small quantities by individual families to meet their own domestic requirements for an indefinitely long period. It is still made by many of the less sophisticated natives, and particularly by the nomadic pastoralists of the east and south-eastern parts of the Musoma district, solely for their own consumption. The method used is a simple one and the quality of the resulting

ghee is poor. Briefly, the method consists of allowing the milk to sour in a large gourd. The gourd is then suspended from the roof of the hut and shaken by the lady of the house until the butter separates. This is scooped out and collected in an earthen pot until sufficient is available to make it worth while boiling into ghee. During the period that the milk stands to sour, and also during the storage of the butter, much dirt and many insects collect on the surface, and a high degree of rancidity develops. Very little of either of these undesirable adjuncts is removed during or after boiling, so that the quality of the ghee cannot be high.

This poor quality ghee was the only type prepared up to 1930, but the quantity produced for sale had gradually increased. In 1930-31 Purvis introduced two separators into the North Mara area and "butter-ghee" was first made. This term has been used for ghee made by first separating cream from milk, allowing the cream to ripen, and then converting the cream into butter, prior to clarification.

The fall in the price of cattle and the economic need for cash led ot the rapid development of this "butter-ghee" industry. Many separators were purchased by natives, chiefly Jaluo from South Kavirondo, who had learnt the process of ghee production in Kenya mission stations. This development was encouraged by Emson, who reported at the end of 1932 that sixty-six separators were in operation and that 50 per cent of the exported product was of the improved "butter-ghee" quality. During 1932 the total export of ghee was but slightly increased but the improved quality of the article led to a big increase in the revenue from this product.

During 1932 a scheme was sanctioned to allow some of the Native Authority funds to be used to establish local natives in the "butter-ghee" industry. Under this scheme a native, who could produce evidence of a sufficient stock wealth as a security, could obtain a separator and churn on loan from the Native Authority. This loan was paid back at the rate of a *debi* (four gallons) of ghee a month. Under this scheme forty-two separator and churn units were issued. At the same time the local Indian traders instituted a similar scheme of issuing separators, but often the Indian retained the ownership of the separator and the native operator received a wage from the Indian.

The number of ghee producing units rapidly increased so that the competition became "cut-throat", and many natives who had obtained a separator and churn under the Native Authority loan, were being crowded out of their "pitch" by natives setting up the separator units financed by Indians. Eventually the Native Authority scheme was abandoned, and the Indian system is the one now in vogue.

The rapid rise in the industry may be judged from the following export figures, which represent only the ghee being exported through Musoma, and do not include the internal Musoma trade, nor the ghee carried over the border into Kenya by individual natives:—

		Exported at a Value of
1931..	2,748·42 Cwt. ..	Sh. 113,216/36
1932..	2,950·16 Cwt. ..	Sh. 157,294/40
1933..	5,442·57 Cwt. ..	Sh. 221,975/70
1934..	7,383·35 Cwt. ..	Sh. 329,886/94
1935..	10,457·00 Cwt. ..	Sh. 475,260/00
1936..	11,823·99 Cwt. ..	Sh. 632,506/82

This year there are over five hundred ghee producing units scattered through the Musoma district, chiefly in North Mara. This probably represents the useful working limit and any further increase in the number of separators will not necessarily be followed by a permanent increase in the output of ghee. Even with

the present number of separators, overcrowding is obvious in certain areas and the owners are working in opposition, to their mutual disadvantage. Much could be done to effect a better distribution of ghee units, with consequent increase in the total output. Although about 70 per cent of the present population are pastoralists, there will almost certainly be an increase in the number of natives engaged in the mining industry, and probably also an increase in the agriculturalists in South Mara. Both these increases will tend to reduce the ghee output of the district. This decrease could be counterbalanced by a better distribution of the existing units, but it is doubtful if an increase in the total number will be advisable.

The Methods of Ghee Production

As already stated, ghee is still being prepared by the old primitive method (shaking soured milk into butter and then boiling the butter) by the nomadic pastoralists of the eastern area, and also by numerous small cattle owners all over the district. This type of ghee compares with the poor grade native made ghee from the Central Province, and does not enter into the export market. It is produced solely for the domestic requirements of the household.

The "butter-ghee" produced for export comes from three types of producing units, which may be classified into:—

I. The native-owned "Separator" unit.
II. The native-owned "Separator and churn" unit.
III. The "Indian *duka*" unit.

The quality of the ghee from these different types of unit does not vary greatly, and fairly good ghee can be produced by any of them. The following notes indicate what can and does take place, but it should be pointed out that the more progressive natives take more trouble and work under cleaner conditions.

The Native-owned "Separator" Unit

This type is by far the most common unit in operation. In the majority of cases the native owner has acquired a separator on the hire purchase system (usually from an Indian) and has arranged to buy cream from his neighbours. The separator is normally erected on the box in which it was delivered, and a number of stones are placed inside the box to keep it firm. The separator may be housed under a small thatched structure or a tree, but is often left completely in the open.

Milk is brought from the surrounding kraals in gourds or earthen pots, and it has been the custom to pour it directly into the separator. As a result of recent efforts by the Veterinary Department the natives are now beginning to use straining cloths to remove some of the dirt and insects prior to separation. The cream from the milk is measured in a small enamel cup ($\frac{1}{8}$ to $\frac{1}{2}$ pint capacity) and is paid for on delivery at the rate of 10 cents a cup. This is a very low price but the natives appear satisfied.

The cream is emptied into a collecting *debi*. Often the amount received daily is very small and it may take three or more days to fill a *debi*. The cream is stored in the *debi* for a few days to ripen and is then stirred with a stick until the butter separates. This is a tedious job, and there is a tendency to leave the cream to become very sour before it is stirred into butter. When this separates, as much butter milk as possible is poured off and the butter set aside to accumulate. The butter is not washed with water to remove all the butter milk and consequently it is very rancid by the time it is boiled into ghee.

When larger amounts of cream are purchased, the cream is stored until six *debis* have collected and then the whole lot is stirred into butter which is boiled the following day.

For the boiling either an earthen pot, an aluminium saucepan or a large iron pan is used. It is set on three large stones over a small fire burning in a shallow depression in the ground. Stirring is performed intermittently with a stick or wooden ladle.

When boiling has finished the ghee is removed in a bowl or kettle for filling into *debis*. The usual procedure is to spread a small (4 inches square) piece of cloth over a small hole in the *debi*, and then to pour the hot ghee through this cloth. This is a long job and, as the piece of cloth is usually very old, the straining process is not very efficient. Much of the protein curd passes into the *debi* of ghee and reduces considerably the keeping quality. Since the protein has already begun to hydrolyse the ghee possesses a pungent cheesy smell from the time it is made.

Usually the ghee made in this way is overboiled and boiled too slowly, so that it fails to solidify on cooling to ordinary temperatures.

The Native Owned "Separator and Churn" Unit

Compared with the previous type a very much smaller number of this kind of unit is in operation. The natives owning both a separator and churn were largely established under the Native Authority Scheme, the use of a churn being advised to improve the quality of the butter and hence the nature of the ghee.

Usually this kind of outfit is set up in a good cattle area, and a larger quantity of cream is purchased than with the "separator" unit. The method of purchase, separating and boiling is exactly as described for the separator unit. The difference in procedure is that with this type the cream is stored until six or so *debis* have collected and soured. The cream is then churned into butter in a rotary metal churn. Again the butter is not washed, although by doing so a very much better quality butter could be produced with this unit than when the butter is made by stirring the cream in a *debi*. In practice there is very little difference to be observed in the quality of the ghee resulting from the two types. There is perhaps slightly less rancidity in the ghee prepared by this type of operator, but I think this is due to the shorter interval between separating and boiling rather than to the outfit.

The "Indian Duka" Unit

This type of ghee producing plant is owned entirely by local Indian traders. The separator is set up outside their shops and milk is purchased in the usual manner. A native is employed by the Indians to do the work, and this type of unit is essentially the same as that in which the separator is owned by a native. The only difference is that the Indian has more capital, and so can buy on a larger scale than the native. Also the native likes this type of unit because he can spend his cream money straight away in the shops.

As a modification of this system, one finds that Indians own several separators which are set up in the nearby village. A native is employed to work and look after the separator and then the cream is brought in to the duka where it is mixed with cream from the duka separator.

The cream is allowed to stand until about six *debis* have been collected and then it is stirred into butter with a stick. No churn is used in this type of unit. Boiling is usually done in a large iron

pan and the process is the same as for the previous two types.

Ghee of the same standard as the previous types is produced.

Improvements Being Encouraged by the Veterinary Department

An Assistant Livestock Officer tours the Musoma district whenever opportunity arises, and gives instruction in methods of making ghee. Great stress is being paid to the question of improved cleanliness of utensils and operators. The use of straining cloths is being urged both for straining the milk and for removing the protein curd from the ghee. Efforts are being made to encourage the use of better fireplaces and the quicker boiling of the butter into ghee. Demonstrations are being held in each sub-district to teach the operators the correct point at which to stop the boiling process, and the correct way to filter off the curd and collect the ghee in containers for export.

Amongst those natives who wish to continue making "butter-ghee" the Veterinary Department is doing its utmost to reduce the time of storage of the cream and butter. Where there is little probability of frequent churnings and boilings the natives are being taught to make their ghee by the direct boiling of cream each day.

The Direct Cream to Ghee Method

Under the existing conditions the cream is allowed to ripen for several days before being churned into butter. The longer the cream is allowed to stand the higher the rancidity and acidity that develops. Further, as the normal butter-making process does not include washing, much of this acidity and rancidity is left in the butter. During the storage of the butter further rancidity and acid-producing changes take place, so that by the time the butter is boiled its quality is often very poor. The boiling process removes much of the rancidity and acidity, but naturally the greater the initial values the greater the amount that will remain in the final ghee.

Therefore, for the production of the best quality ghee the cream and butter should not be allowed to stand longer than is absolutely necessary. Under the present conditions, the daily cream purchase is, with but few exceptions, too small to make it worth a native's while to go through the laborious and slow business of stirring the cream into butter.

With the existing conditions of a small daily supply of cream, there is no alternative but to abandon the present system completely. In its place each day's supply of cream should be boiled directly into ghee on the day of separation and without the intermediate step of making butter.

Tests in the laboratory and at the Clarified Butter Factories have shown that ghee made by the direct boiling of cream does not develop rancidity or high acidity. Also once butter-fat has been freed of moisture and proteins it can be stored almost indefinitely without fear of deterioration. It seems, therefore, that the logical procedure in Musoma, where only small quantities of cream are available daily, is to convert the cream into ghee directly, eliminate the laborious butter-making process and thereby obtain a better quality article.

In the Government supervised Clarified Butter centres of the Western Province, it has been the practice to mix the cream with water and re-separate to reduce the protein content of the cream. Under the Musoma conditions where very much smaller quantities of cream have to be dealt with, this re-washing of the cream is unnecessary.

Demonstrations of the method have been given in 1936 and many natives are taking up this simplified process and thereby obtaining a better quality ghee for which the Indian dealers are paying a higher price.

Briefly, the cream is boiled as soon as possible after being separated from the milk. Quick boiling is advised and when the protein curd has sedimented the boiling pan is taken off the fire and allowed to cool. The contents are then strained through four layers of cloth into an open vessel. The last dregs of fat are squeezed out of the curd by twisting the ends of the cloth, and it is recommended that these last portions be collected separately and reboiled with the next day's cream. This prevents any curd being poured into the exporting container and the quality of the ghee is considerably enhanced thereby.

The extra price being paid for this better quality product, which does not involve extra labour in preparation, is proving a sufficient incentive for the wider use of this direct method.

Quality of Musoma Ghee

Average Musoma "butter-ghee" is a semi-solid article, the amount of solid varying considerably. The ghee is not free completely from protein material and possesses a pungent cheesy smell. Its rancidity varies greatly between individual samples, as does also the solidity and the extent of protein and dirt contamination. The variation in quality is a result of the long intervals of storage of the cream and butter, and of differences in the efficiency of the clarifying technique. Nevertheless, on the whole the quality of this "butter-ghee" during the last few years has been definitely superior to that of the ordinary native-made product from other parts of the Territory. Similarly the ghee made by the direct boiling of cream without any interval of storage and ripening is very much superior to the "butter-ghee". It is highly probable that if this direct cream method increases in popularity a product will be marketed from Musoma which may challenge the supreme position of the Government Certified Clarified Butter.

It is seen, therefore, that Musoma ghee varies considerably in quality. The best article is comparable with the Clarified Butter sold for European consumption; it is free from rancidity and proteins, and is solid, but the good name which might be enjoyed by these best samples is kept tarnished by the presence in the same consignment of ghee of poorer quality.

Marketing of Musoma Ghee

This branch of the industry is at present almost entirely in the hands of Indians. These traders generally buy the ghee from the native producers, grade it, and then export it to various places according to the quality of the product that is required. Musoma ghee has become well known, and Indian traders have built up connexions which appear to be capable of absorbing more than the present production. It is transported long distances, as far, it is said, as the Persian Gulf.

The present marketing system appears to be working satisfactorily for all parties concerned, and no interference is contemplated. It is considered that the best way of furthering the industry is to improve the quality without making drastic alterations in existing methods of production, and to reply on the better quality ghee commanding a better price.

Pasture Problems in the Trans Nzoia

By M. HALCROW, *B.Sc. (Edin.), Dip. Agric. (Edin.), A.I.C.T.A., Agricultural Officer, Department of Agriculture, Kenya Colony.*

The most obvious feature of the pasture of the Trans Nzoia is its superabundance during the rains and its comparative scarcity during the dry season. This state of affairs is of little consequence on the completely mechanized farm; and it is only during particularly severe dry seasons that it assumes much importance on ox-cultivated maize farms. But the advent of mixed farming, and particularly dairying, has made it a problem that calls for immediate attention.

The grasses mostly present in the Trans Nzoia are *Themeda triandra* (Red Oat Grass) and *Hyparrhenia* sp., with *Trichopterix* sp. commonly as a bottom grass. The grazing is sweet at the beginning of the season, that is from March to June. In June, however, the *Hyparrhenia* shoots up its flowering spikes to three feet or more, with the result that the herbage rapidly assumes the character of a small grains stubble. The tall spikes are hard and unpalatable, and naturally stock prefer to walk through them with an eye to possible patches of low-growing couch grass or other more succulent herbage, like that frequently found on roadsides and under shady trees. This brings about a considerable reduction in the carrying capacity during the rains. Thereafter, the carrying capacity is still further reduced, because the grasses, while they are able to survive the dry season, make little or no growth during this period. In truth, land occupied by the tall grass species has a very short period of usefulness. The tall spikes ultimately fall or are trampled down to form a close mulch of decaying straw, through which only the coarse, vigorous grasses (from which the mulch is derived in the first place) are able to make new growth. The finer bottom grasses are smothered. The tall species are, in the young state, palatable enough for stock, but as already mentioned they run to seed too rapidly and have a low proportion of leaf to stem. The native habit of putting a fire through the pasture as soon as it is dry enough has the advantage of enabling the stock to eat off the young shoots as they appear; whereas, if burning is avoided and the old dry fog is left, the shoots are comparatively old by the time they get through it. Unfortunately, burning has the same effect on the bottom grasses as fog; only the tall, coarse species appear to survive the fire. There is no doubt that complete control of the pasturage in all its stages is desirable; it is the best method that requires elucidation.

There would appear to be three ways of attaining controlled pasturage. The most obvious way is by means of a grass mowing machine. This has the advantage not only of controlling the pasturage from the grazing point of view, but also of providing hay fodder for use during the dry season. It has been found that mowing is best employed in conjunction with the second method, namely paddocking, to enable severe grazing during the period March to June. Theoretically, this second way by itself is ideal, but in practice such heavy grazing is required, so rapid is the growth, that the actual area controlled is almost negligible. The numbers of stock required to control all the grazing in this way would be much in excess of its dry season capacity, even with the provision of supplements, so that to employ this method alone is out of the question. Experience is showing that close

grazing in fenced paddocks with the use of a mower not only gives control of the pasturage but actually brings about an improvement in it. To quote A. G. Lindsay, Esq., of Suam, Uganda, whose grazing comprises seven 25-acre and two 50-acre paddocks: "With rotational grazing and mowing the sward thickens. There is a tendency for oat grass to be replaced by other varieties of grass for which we have names but not their botanical names. With rotational grazing and mowing the feed per acre definitely increases, but the actual improvement in the type of grass is very slow. By paddocking, the tick population definitely decreases without dipping. If veldt is treated as a meadow the improvement in the sward is not so marked, but the sward improves if cattle are grazed on the aftermath." These conclusions will be readily corroborated by experienced stock farmers in the Trans Nzoia.

A third equally obvious way of improving the grazing is the introduction of pasture species that can be relied on to produce green feed during the dry season while at the same time remaining comparatively free from tall flowering stems during the rainy season. In the circumstances, this would appear to be "hitching one's wagon to a star." The soil of the Trans Nzoia is very sandy, and as a result extremely well drained. Three weeks without rain, even in the wet season, is enough to make the average kitchen garden look distinctly "thirsty". It is indeed asking a lot of a grass to withstand a three to four months dry spell, and at other seasons a good deal of wet. The average rainfall of the Trans Nzoia is 45 to 50 inches, usually from March to November. Nevertheless, some measure of success appears possible with such drought-resistant species as Molasses grass (*Melinus minutiflora*), Star grass (*Cynodon plectostachyum*), *Paspalum dilatatum*, Kikuyu grass (*Pennisetum clandestinum*), and Rhodes grass (*Chloris gayana*). One thing, however, is necessary for the proper maintenance of all those species, and that is a high level of fertility, whether by means of additional organic matter or by adequate cultural operations. While undoubtedly organic matter is often a limiting factor, a good open physical condition of the soil is essential. Experience is showing that the latter is of paramount importance, and the rotation of grassland with arable is possibly the best means of controlling pasturage.

At the present time, most progressive stock farmers in this area content themselves with a combination of paddocking and mowing. In some cases paddocks have been planted up. Haymaking is exceptional, in spite of the fact that the low carrying capacity during the dry season is the grazier's biggest problem. To overcome this, varying acreages of Napier grass (*Pennisetum purpureum*) have been planted, through which the cattle walk daily, or the leaves may be cut for bedding. The disadvantage of Napier grass is that without attention it deteriorates and finally presents a difficult problem when an attempt is made to bring the land back into cultivation. Several farmers have planted drought-resistant pastures, mostly using Kikuyu grass; but in general the same deterioration sets in, except round milking sheds, *bomas*, gates and the like, where the growth becomes extremely rank owing to heavy dressings of dung. The attempt to use the beneficial effect of severe trampling by the provision of movable *bomas* is still in the experimental stage. Major A. G. Keyser, of Kitale, runs two movable night *bomas*. Cyclone "Ringlock" cattle fencing is used, each *boma* being about half an acre. One holds 150 to 200 head of store cattle for about ten days, after which it is moved to the new site. Since the cattle brought in at night

have fed elsewhere during the day, the *boma* is treated at the expense of some other part of the farm, which, however, is probably deriving considerable benefit from being grazed down. The fact that much of the land treated by this means has to stand exposed to the dry season, which must burn up most, if not all, of the organic matter left on the surface, is a difficult problem. Clearly the humus can be conserved by ploughing it in, but in the dry season this involves killing the herbage. Major Keyser's present idea is to run the night *bomas* slowly over the entire paddock and during the next rains to plough up the sward. It is well known that ploughing local Rhodes grass, Kikuyu and Star grass during the rains has an extremely beneficial effect on the herbage. The application of this fact seems a logical step towards the solution of the problem of preventing deterioration in grassland.

Artificial fertilizers as a means of improving grassland in the Trans Nzoia offer little hope. Sulphate of ammonia improves the growth, but only temporarily, and then, as grassland research in other parts has proved, probably at the expense of the feeding value. Results with phosphate have been inconclusive. This is not altogether to be wondered at in view of the inconclusive results with the local arable crops and the fact that the benefit from phosphate on grassland usually lies in the improved growth of the clover constituents, which are absent in the Trans Nzoia. Lime and potash also are of doubtful efficacy; though potash has given slight improvements, the expense would rule it out. While the general statement, that artificials offer little hope as a means of improving pastures, is true for the present, it may well be that the use of phosphate will solve the legume problem, or alternatively, if suitable pasture legumes are discovered, it is almost certain that phosphate will come into its own. Nevertheless, it is clear that, as with all other crops in the Trans Nzoia, the improvement of the soil for better grassland lies in improving its physical condition by the incorporation of organic matter.

For farmers who have not quite decided what to do to improve the pasturage on their farms, a few suggestions may be acceptable. The advantage of paddocks of some kind is now more or less accepted. Grass-cutting is inevitable, and a mowing machine will almost certainly be necessary. Owing to the carefree attitude of native labour, upkeep costs are high, and usually one is inclined to restrict the use of the mower to the minimum. In this connexion one or two planted paddocks of short grass species, such as Kikuyu, Star grass, and Molasses grass, will be found desirable. For hygienic reasons, these short grasses are best planted near the house and buildings, and if necessary on boundaries to prevent the incursion of grass fires. Paddocks of all the above grasses are easily established from roots or cuttings. Where high-class hay is required the use of Rhodes grass as a temporary ley is recommended. The rotation of arable land with pasture, which may be useful for the mixed farm, is under trial at the moment. Where dairying only is being practised, planted paddocks may require compost through a distributor and wet-weather ploughing every few years, to keep them in good order. A useful standard to aim at is that the average height of the herbage should be not less than about four inches when the paddock is due for grazing. It will be found that Kikuyu grass paddocks in the Trans Nzoia have to be in good heart to attain this. Lastly, it is strongly recommended that, in spite of weather and other difficulties, a real attempt should be made to secure a crop of good hay, veldt or Rhodes, as a dry-weather reserve.

To appreciate the value of hay as a nutritive roughage in rations, quite apart from its use in pasture management, it is interesting to know that, where adequate drinking water is available, cows do just as well on good hay as on silage. Green grass has a high feeding value, and it has been amply demonstrated that none of that value need be lost if the grass is cut and properly cured. The protein or body-building constituents are the most valuable because they are expensive to buy, e.g. groundnut cake, lucerne meal, etc. And, as young grass has proportionately more protein than old, the necessity for making hay before the grass starts seeding is obvious. The younger the grass the better; but usually, to enable the greatest bulk to be obtained at one cutting, at or just before flowering is the best time. Well cured hay is green in colour, and to obtain this quality it is necessary to avoid the effects of both sun and rain, and to get the crop in permanent stacks as quickly as possible after curing. From the foregoing it will be readily appreciated that under Trans Nzoia conditions the individual farmer must work out the most convenient system for his particular conditions.

Personal experience indicates that June is probably the best time for haymaking, as it is a fairly dry month and also the veldt is just about right for cutting. The grass is cut in the early morning, and if the day is hot the swathe can be turned in the afternoon. Next day, if possible, or the day after, the grass is built into smallish cocks. A hay rake and a few forks will be found useful for rapid handling.

Personal supervision of the putting up of the cocks is essential. These are built up layer by layer, about five feet wide and six feet high, coming to a point at the top. It is essential to see that the tops are properly made to run off rain if required; this is largely the secret of success. Cocks should be tidy round the bottoms to save wastage. The grass can be left like this until it is convenient to move it or to build large hay stacks. If the weather is right, stacking can be done in ten to fourteen days after cutting. If possible, a covered *boma* or shed should be used, in which the hay is tramped as tight as possible. Alternatively, round stacks can be built on a base about ten feet in diameter. Such stacks must be tightly packed and thoroughly topped out at fifteen feet so as to run off all rain. If rain interferes with the work, a tarpaulin should be tied down on top. Completed stacks with the tops tied down by hay ropes can be thatched if required.

All these operations may appear laborious, but it is soon apparent that only by attention to detail can success be achieved. Good hay is a valuable commodity, particularly in raising young stock; it will make all the difference in the world in the appearance of the beasts in the dry weather and prevent that "weak hindquarters" appearance too common among young stock, especially grades, in these parts. The so-called "cream-cheque sickness," from which weanlings so often suffer, can be largely overcome by the provision of first-class hay during this critical period.

Farm Fencing—Part III

By L. A. Elmer, *Assistant Agricultural Officer, Department of Agriculture, Kenya Colony.*

Erecting the Fence

At the particular request of an old settler, mention is made of the desirability of making sure the fence is on the right line. He stated he had known of several fences put up on the wrong farms; and even a few feet across a neighbour's boundary may cause trouble. Once the line is selected it should be cleared thoroughly and ant-hills cut down to a gentle slope. Small depressions should be filled in. The cleared line should be wide enough on one side to allow a cart or wagon to pass with posts and to facilitate regular patrolling of the line.

The dimensions given below apply to a fence 4 feet high, but the general principles apply to all fences whether 10 yards or 10 miles long.

Marking the Line

On undulating land and for long lines mark out with a few tall straight sighting poles, flagged with paper or white cloth. A pair of field glasses is useful for sighting over long distances.

Then cut a number of thin straight stakes, pointed at one end as follows:—

3 ft. stakes to mark the places for post holes.

4 ft. 6 in. stakes to mark the places for post holes.

6 ft. stakes to mark the places for corner and gate posts.

These should be driven in for at least a foot at the right places. A wire or rope of the right length will do to measure the distance between posts. While this is being done a note should be made of any hollow or rise in the ground, and the position of the post altered or an extra post allotted.

Careful note should be made of hollows, as fence posts taking an upward strain must be fitted with foot-plates to prevent them being drawn up out of the ground by the upward pull of the wires.

The measuring rope stretched will serve as a guide to the height of the bottom wire when deciding where an extra post is needed. A rough diagram of the fence line is useful.

When marking out is done the clearing for the cart tracks should be widened where necessary.

If wooden posts are used, it is an advantage to mark on the butt end of each the correct distance is should be sunk in the ground. They can now be loaded up (referring to the diagram of the fence line), and the cart can dump each post by the right stake, stays and pickets or stones by each strainer and corner post. It is a saving of trouble if this work is checked before the next operation.

Holes

Holes should be only a little larger than the posts. If rocks are found close below the surface it is better to move the position of a post than to batter a hole in hard rock. Care should be taken that the new hole is in the line of the fence. If a wide stretch of rock has to be crossed, one or more steel standards can be concreted in. In bad holding ground, such as black cotton soil, larger holes are made and gravel, stones or murrum carted to fill in for ramming.

Holes for strainers should be 3 ft. 6 in. deep and be shaped to take the foot-plates across the lines of the fence.

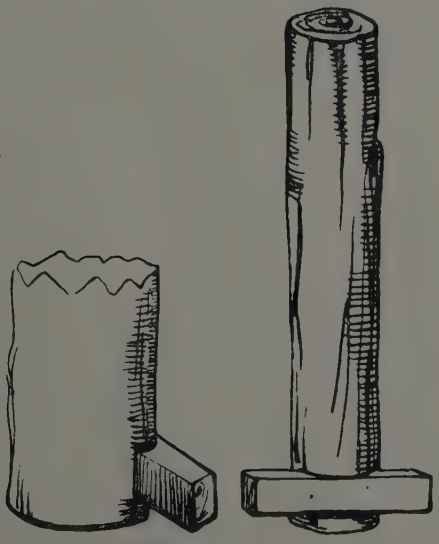
When deep holes are being dug without an augur, a shallow depression made at

the side of the hole will allow the labourer to get his shoulder well down so that his arm can reach the bottom.

Each digger should be provided with a measure and be told to heap the excavated soil six inches from the hole. Grass and roots should be thrown well away, as rotting vegetation in a hole will cause the posts to loosen. If a coffee holing tool is used it should have a four-foot handle, to allow some force to be used when digging near the bottom. A hardwood stake, sharpened to a chisel point, is a cheap and effective tool for digging holes in fairly soft ground, but needs sharpening from time to time.

Foot-plates (*Figs.* 1 *and* 2)

The foot-plates can be fastened to strainers and posts in hollows before taking them out to the field, but they may get knocked off in transit, and it is usually better to fix them on the posts when they are laid in position.



FIGS 1 AND 2

Cut a check 3 in. wide and 1 in. deep into the butt of the post to allow the 3 in. x 2 in. plate to fit exactly; bore holes with a nail bit and nail on with two 4 in. nails. If the ramming is done properly the plate will never come adrift. It should be one inch from the bottom of the post. When the post is planted, the plate should be on the opposite side from which the first strain will come.

If the posts are treated with preservative, it is an advantage to cut the checks to receive foot-plates before treatment.

Ramming

When the holes are dug, go round with a few boys and place the posts upright in the holes. If the posts are not exactly round or are split from big logs, the greater cross section should be at right angles to the line of the fence. Each man will hold a post, and a sight should be taken to see if they are in line. When they are aligned correctly each man can push in a foot of subsoil with his feet, and ram to hold the post. After this, another sight should be taken to align the tops and more ramming done to hold the post firmly.

The posts can then be left to the rammers, who should ram the soil already there until the post is absolutely firm, and then add six inches more at a time and ram until hard. The best state of the soil is dry or nearly dry. Ram with a pointed hardwood stake, about eight feet long, not so thick as to prevent it from reaching the bottom of the hole. Ramming must be carefully done around anchors and foot-plates.

Ramming at the top is much less important than at the bottom. If the soil is wet do not ram much and put stones or murrum in with the damp soil. The addition of stones to dry soil does not help the

firmness to any noticeable extent. After ramming, the balance of the soil should be packed round the post to prevent a depression in which water can collect.

Where the fence runs down a hillside, posts should be at right angles to the ground and not perpendicular.

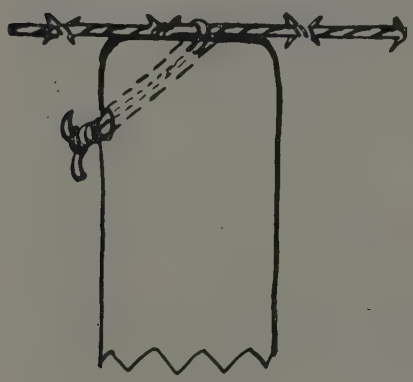


Fig 3

Boring Holes in Posts

This is best done after the posts are up, as they may turn in the ground when being rammed. The holes must follow the line the wires will take and be bored right through, to clear out any debris, which might prevent easy threading. Holes five-eighths of an inch in diameter are the best size. With posts that have been treated with preservative, these holes should be painted inside, using a bottle brush and creosote. For very hard wood, such as olive, one augur will be worn out every half mile or so. A marked staff helps to measure the spaces quickly.

If a barbed wire is required on top it is best laid on top and tied as illustrated in Fig. 3 with No. 12 wire through a hole bored diagonally $2\frac{1}{2}$ inches from the top. Staples are liable to pull out.

Staying or Strutting Straining and Corner Posts

Each corner post should have two stays just inside and close to the wires, or one just inside and one just outside. Except with obtuse angles, it is better not to put a stay to divide the interior angle, as it may trip up big stock. A corner post is almost always used as a straining post, and has to have two stays, so there is no advantage in an interior stay except when the angle is much greater than 90 degrees. Each straining post must have one stay fitted, care being taken that it is on the side from whence the first strain will come.

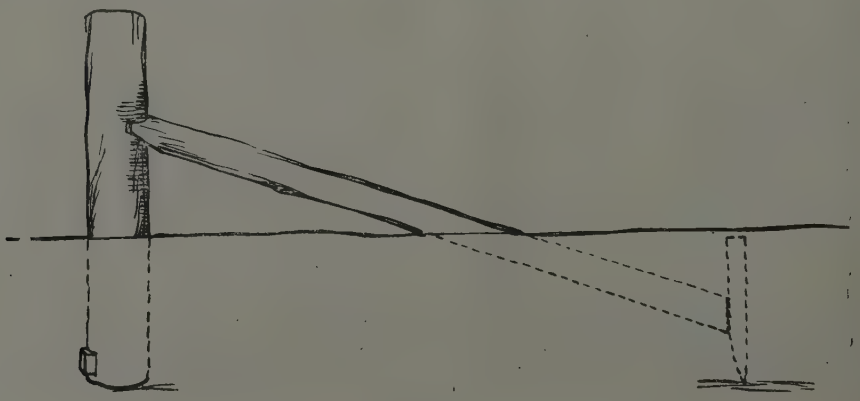


Fig 4

If a steep valley has to be crossed, a strainer should be placed at the top and bottom of each slope, even though the lower strainer posts come close together. The foot-plates of strainers subject to an extra upward pull must be longer in proportion. When the ground falls away abruptly from a strainer, use a longer stay or anchor the post the other side. If a wire cable is liable to damage stock, make a wooden anchor with a stay timber.

Mark the post 22 inches from the top for the mortise holes (Fig. 4). These should be a little on one side of the wire holes to allow free passage for the wires. Bore one-inch holes to a depth of one inch around the mark, and make a mortise about 4 in. x 3 in. With a saw, cut the thin end of the stay to fit the face, and trim it to fit the mortise hole.

The butt end of the stay should also be cut at the right angle to allow the picket post to fit snugly against it. If treated timbers are used, the fresh cuts should be painted with creosote.

The stay can now be held to the post to measure a trench, which should be dug at least 18 inches deep, sloping up towards the post. Care should be taken not to disturb the soil unnecessarily; when the stay is placed, knock in a picket post against the end, the two flat surfaces together. Then replace soil, and ram. A hoe, mattock and shovel are the quickest tools for digging these trenches.

If a big stone be used instead of the picket post, it should be tamped well into position; a good footing for the stay is essential.

With iron standards use metal anchors and foot-plates. Old discs will serve (Fig. 5). The wire anchor cable should not be used where it will trip up animals.

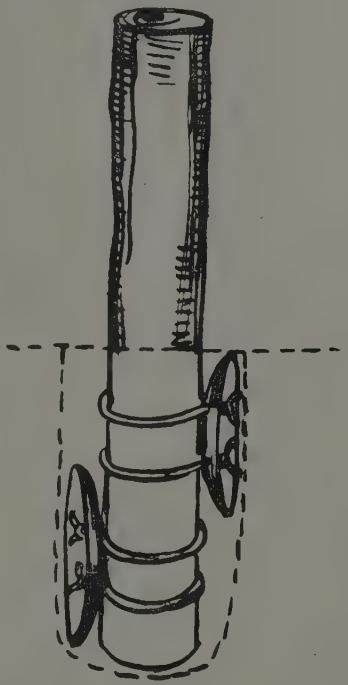


Fig 5

Concreting iron straining and corner posts is very effective, but the concrete must be allowed to set thoroughly before the wires are strained.

(To be continued)

Sheep Scab in Kenya Colony

By E. ANEURIN LEWIS, *B.Sc. (Agric.), M.Sc., Ph.D., Entomologist, Veterinary Department, Kenya Colony.*

INTRODUCTION

The prosperity of sheep farming in Kenya, as in other countries, is dependent upon the production and disposal of mutton or sheep or wool.

The chief woolled sheep raising districts in the Colony are Laikipia, Naivasha, Nakuru and North Nyeri, where flocks may comprise two or three thousand sheep or as many as twenty thousand or more. Smaller flocks—with several hundred sheep—are kept on cattle farms and where mixed farming is practised. Still smaller numbers of woolled sheep belong to natives resident on European farms and even in parts of the native reserves.

To the owners of small flocks whose major concern is beef and mutton production or dairying, the sheep provides both meat and wool, but its services are farther-reaching; it clears and improves the pastures; it provides more and sweeter grass for other stock. The rich manure is spread over the land by the animals and it restores impoverished soil to good heart. Despite its utility, the sheep on such farms and in crop-producing districts is considered to be of minor importance; it may receive appropriate attention in the general management of the farm.

The sheep farmer, however, has to rely on the sale of sheep and wool as the principal source of his income. Hitherto there has been no satisfactory outlet for his surplus stock, and the natural multiplication of the animals has, in many cases, led to the heavy losses that not infrequently accompany uncontrolled increase of numbers. The success of many a sheep farmer in this Colony has been based on his ability to produce a sufficient crop of good quality wool.

Sheep scab is a great menace to wool production; it depletes the profits of the flockmaster; considerable outlay of capital and extra labour are entailed in measures for its control. In a young colony like Kenya, it hinders the development of a striving and hopeful industry. The importance attached to the disease in the country is revealed in the history of sheep farming and the efforts of early pioneers to establish a sheep industry; and in the discussions held in conferences of stockowners. Stordy (1907) refers to sheep scab in his report for the year 1905-06. He states, "Until recently we have only had one outbreak of sheep mange [*sic*], and I had considered that East Africa was free from the disease. Two outbreaks have, however, occurred quite recently, one on the Government Farm, Nairobi, and one at Lord Delamere's farm at Soysambu. Compulsory dipping is being instituted, and every means possible will be enforced to get the disease in hand. The danger from this disease is increased by the constant moving of native flocks, such movement being so difficult to control. It is worthy of note that on the hairy native sheep the disease is not of a virulent nature, one dipping having proved sufficient to destroy the acari."

Mr. W. E. Powys (1936) writes in *The Story of Sheep Farming in Kenya,* "The grim necessity of dealing promptly with ever-recurring outbreaks of scab every few months was the first reason for half-yearly shearing; but since we have no winter to contend with, as is the case in almost all other wool-producing countries, many flockowners find it better for the sheep and more profitable to shear every six months."

Although confronted with the obstacles presented by sheep scab and losses due to many other diseases, sheep farming in Kenya has developed gradually but surely and wool production has increased considerably since the early pioneering days.

The following table illustrates the growth and development and the economic importance of the wool industry:—

Year	Quantity of Wool	Value
	Cwt.	£
1914	1,965	9,044
1920	3,351	21,110
1928	7,880	103,040
1929	9,135	98,872
1930	8,335	70,615
1931	7,784	43,427
1932	8,503	39,293
1933	8,330	38,481
1934	10,022	30,037
1935	12,626	41,710
1936	13,026	44,174

How much sheep scab has affected the quality, quantity and the price of wool cannot be estimated. It is fairly certain that, if the figures quoted above indicate the maximum possible development of wool production under existing conditions, it may be necessary to concentrate on improving the circumstances in which wool is now produced. Sheep scab will then become of greater economic significance than it is to-day. Its harmful effects have long been appreciated by sheep farmers.

At the Stockowners' Conference held in Nairobi in September, 1930, the following resolution was passed: "That this Conference is of the opinion that Kenya will never justify herself as a wool-producing country until sheep scab is brought under control, and therefore begs Government to institute further research into the life-cycle of the parasite in Kenya and into the conditions prevailing which seem to render the eradication of the disease impossible, with a view to making the ultimate application of a scab law possible."

In response to this request, I carried out a series of observations on the life-cycle of the sheep scab mite, *Psoroptes communis* var. *ovis*, at the Veterinary Research Laboratory, Kabete. The results were circulated to a number of farmers concerned. No details were given, as it was thought essential only to acquaint the farmers with data on which to calculate the intervals between dippings.

Life-cycle of the Scab Mites

Studies of the development of the mite on sheep were conducted during October to December, 1930, and again from May to June, 1931. It is worth noting that the infestation of sheep, in the first period, by placing a few live mites on the skin was not always so simple or so successful as it might appear. The "artificially infested" sheep were turned into a small fenced paddock, where the available grazing was supplemented by feeding lucerne. A number of animals "infested" in October and November were left in the paddocks until December, when they were carefully examined. There were no symptoms of sheep scab and no mites were found after several hours of searching. These sheep were originally free from scab mites and had not been dipped for months.

A few fully developed females of the mite placed on other sheep began to lay eggs within forty-eight hours. In one case, out of five, a female began to deposit eggs within twenty-four hours. It was not possible to ascertain whether or not this female had already begun oviposition on the sheep from which it was collected. At this stage it was only necessary to obtain as many eggs as possible in order to transfer them to another clean sheep for further examination.

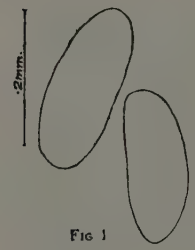


FIG 1

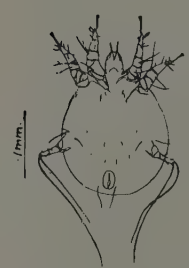


FIG 2

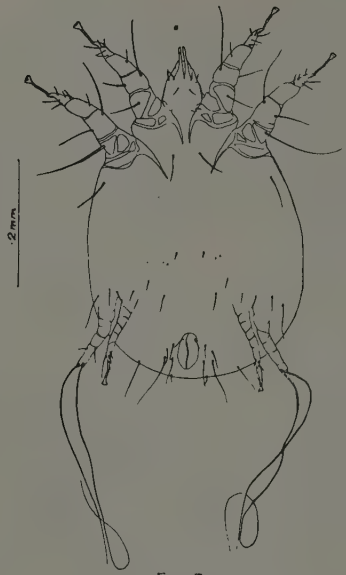


FIG 3

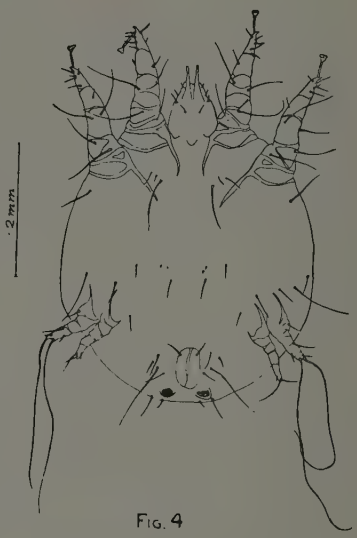


FIG. 4

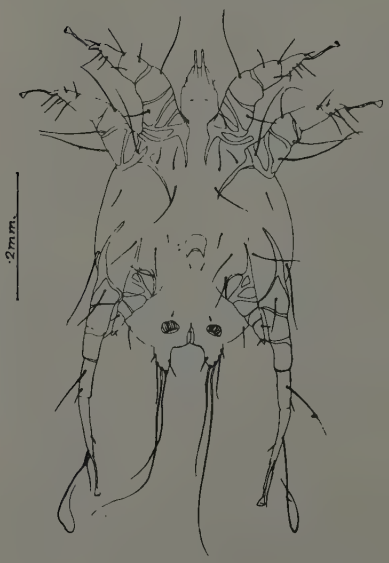


FIG 5

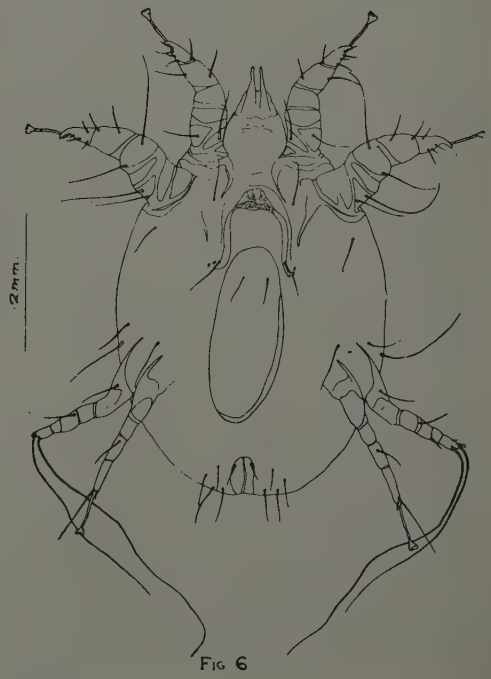


FIG 6

The eggs of the mite (Fig. 1) are extremely small, elongated and pearly-white in appearance; they are usually deposited on the skin at or near the site where the female feeds. In the small number of observations made, the eggs hatched in forty-eight hours from the time they were deposited. Some were observed to take a little longer. The records of late hatchings were not made in these preliminary studies. It was considered sufficient to ascertain the shortest period of development only and to provide this information for advisory purposes.

The larva (Fig. 2) emerging from the egg is a tiny creature possessing three pairs of legs. It soon begins to feed, giving rise to a small inflamed papule at the place where it pierces the skin of the sheep. It feeds and then rests before casting its skin. The moulting takes place in forty-eight or fifty-six hours after the larva has come out of the egg.

The mite has now developed into a nympha (Fig. 3). It is larger than the larva and has four pairs of legs, the first, second and fourth pairs having segmented pedunculated suckers, while the third pair has long threadlike hairs or setae.

The nympha feeds for several hours; and at the site of feeding produces, as in the case of the larva, a minute inflammatory lesion that forms the initial cause of sheep scab. At the end of forty-eight hours —or about fifty-six to sixty hours in some instances—the nympha moults and passes into the adult phase, issuing from its skin either as a pubescent female (Fig. 4) or as a male (Fig. 5). The latter is easily distinguished from all other forms by the posterior processes, each provided with long hairs or bristles; and by the copulatory suckers situated at each side of the ventral anus. Suckers on segmented pedicles occur on the first, second and third pairs of legs of the male.

The pubescent female has pedunculated suckers only on the first two pairs of legs; the third pair has long hairs, and the last pair has short hairs instead of suckers. Immediately behind the cloaca, the pubescent female is provided with two copulatory suckers. No eggs are produced by this female.

It is at this phase of development that fertilization takes place; it is achieved by the union of the male and pubescent female held together by the respective posterior suckers.

The female now changes into the ovigerous female (Fig. 6). The skin is shed and the ovigerous female emerges at an average period of forty-eight hours after copulation. The shortest period observed was thirty hours, the longest fifty hours.

Oviposition commenced from twenty-four to forty-eight hours after the first appearance of the ovigerous or egg-laying female.

These observations were made on the development of the mite on woolled sheep. Another series of experiments was carried out with the parasite on hairy native sheep. The life-cycle was similar to that on woolled sheep, the shortest period of development being eight and a half days. In some cases the period extended to nine, nine and a half and a few hours over ten days.

There was no significant difference between the life-cycle during October to November and the period of May to June.

So far the information gleaned from these experiments does not differ from that obtained from studies in other countries. The observations are admittedly incomplete and further investigations may show that the period of development is longer under conditions less favourable to the parasite.

Influence of Climate

An investigation limited to the academic study of development is obviously insufficient to guide the practical farmer to adopt economic measures to control the parasite. Stockman (1910) and Downing (1936) in England, Shilston (1916) and Bedford (1916) in South Africa, and workers in other countries have shown that the rate of reproduction and the activity of the scab mite are influenced by the atmospheric conditions, the local and immediate environment, and the condition and treatment of the sheep.

Shilston remarks that observations made in Natal for two years showed that there was little difference in the length of time required for the complete life-cycle of the acarus at different seasons of the year, provided that the temperature of the air was the only variant factor.

Bedford, at Onderstepoort, states that the cycle was exactly the same throughout the year although climatic conditions vary somewhat. Shilston gives a case where oviposition was slow towards the end of the long drought, but with the advent of rain oviposition was accelerated. He states in reference to this case: "The commencement of active oviposition with the onset of the rains appears to be more than a coincidence in view of the small production in this and other observations made during the dry seasons and the rapid laying exhibited by the acari when the atmosphere became moist. The sheep themselves were not actually exposed to the rain, but kept in covered pens."

Downing summarizes some of his observations by stating that the variation in the rate of oviposition appears to be dependent upon: (1) temperature and possibly humidity, (2) some form of skin reaction inimical to the parasite. He goes on to say that "sheep which are heavily infected in winter recover spontaneously in the summer. This recovery may be complete, or more frequently is followed by a relapse in the following autumn, the scab having remained latent through the summer. In all such cases acari are continuously present throughout the latent period, whereas in cases of complete recovery the acari have failed to survive the complete latent period."

It is not possible here to deal with the many interesting points discussed in this excellent paper by Downing. He has shown that prolonged careful investigations can be of great practical value.

There is one aspect of the question, however, that may be of especial interest to the sheep farmer and the researcher. It is that in England "latency coincides with the onset of warmer temperatures, endures through the period of warm weather and relapses to activity as the temperature falls in August and September. Downing shows that cold climatic conditions are favourable to a high rate of oviposition; the mites (present in latent infection) begin to migrate, feed and create a zone of active scab. As the minimum temperature falls, so do the mites become more active. The higher the minimum temperature, the lower is the rate of oviposition and the longer is the life of the ovigerous female. There seems to be no correlation between rainfall and scab activity in England.

What is the position in Kenya? Is sheep scab more active during the rains than it is immediately after and during the cold weather of June to August? And do the short rains late in the year bring about a renewed activity on the part of the parasite?

From figures and information supplied by the British East Africa Meteorological Service, Nairobi, the general weather conditions in Kenya may be tabulated as follows:—

Short Dry Period.—From middle of December to early March. January is cool and bright, and the temperature rises up to

the end of March or until the "long rains" have set in. This short dry period is broken by "grass rains" in February and early March.

"Long Rains" Period.—From late March to late May.

Long Dry Period.—From June to October (east of the Rift Valley). From June to August occurs the coldest period of the year and it is usually cloudy.

"Short Rains" Period.—From late October to middle of December.

This general system is modified and varies to some extent according to physical features and the situation of a locality or district. A set of diagrams showing the trend of monthly means of the maximum and minimum temperatures and of the rainfall in each of the most dense sheep districts in the Colony is given in Fig. 7.

If rainfall is followed by an increase in the number of outbreaks of scab or by a greater activity of the parasite, then there are at least two periods in a year when the disease should be prevalent, namely April to May and, according to the locality, October to November or July to August.

If cold weather activates the disease, sheep scab may be expected to appear about May, persist to the end of August, and then disappear with possibly a slight relapse in November. This, as may be seen, is according to maximum temperatures. Estimating by the fall in the minimum temperatures, and according to Downing's findings in the temperate climate of England, the disease might be most severe in Laikipia, Nakuru and Naivasha during November to January or February. During late February, March and April the disease would disappear or enter its latent phase. Theoretically, a recrudescence would take place in May or June, followed by reduced activity. North Nyeri experiences low temperatures (both maximum and minimum) during July to August, and again (minimum temperature only) in January, and it is at these periods that scab would be expected to gain ground if the temperature were the major influencing factor.

Downing expresses the opinion that it would be unwise to compare conditions in Natal and Great Britain, since in England, even during the fine weather, the exceptionally dry conditions of Natal are not experienced. The climate of the Kenya highlands differs from that of Britain and of South Africa. The cold weather period or winter, from about June to August, is not so intense, nor does the low temperature last as long as it does in either Natal or England. The range of temperatures is small, the minimum varying only about five or six degrees and the maximum about nine or ten degrees.

In view of these facts, it is not unreasonable to assume that either the general climate of Kenya does not furnish ideal conditions for the scab mite to flourish or that the parasite responds to our peculiar seasonal fluctuations somewhat differently from its behaviour in temperate countries.

It is on this aspect of the scab problem that further investigations are required. Sheep scab is not a notifiable disease in the Colony. Consequently there are no accurate data on the exact distribution of the disease nor information on differences, if any, in its severity in areas of dissimilar climatic conditions; and there is insufficient evidence to show whether or not the parasite is definitely more active in one season or another.

Observations on seasonal differences in the activity of the mite are being conducted at the Veterinary Research Laboratory, Kabete, and it is hoped that it will be possible to publish the results later. In the meantime, I would urge sheep farmers to co-operate in the investigation

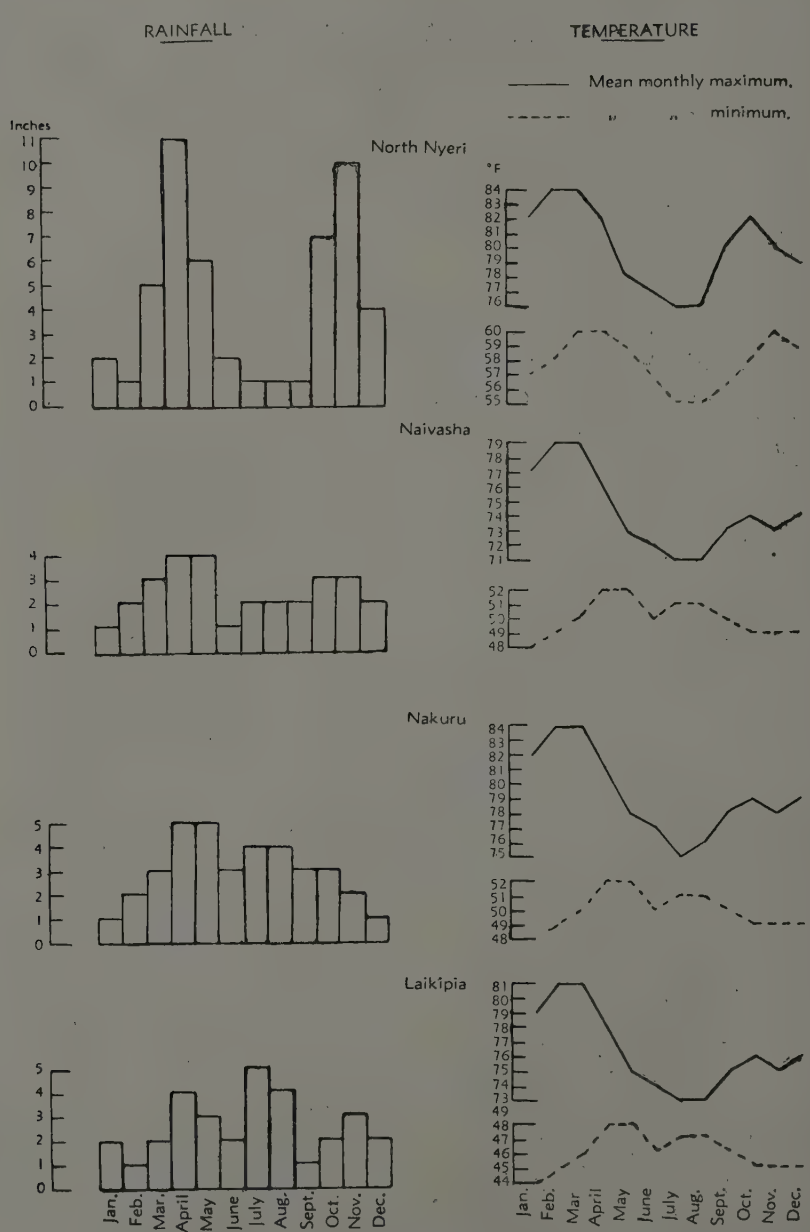

RAINFALL
TEMPERATURE
Mean monthly maximum.
minimum.
Inches
°F
North Nyeri
Naivasha
Nakuru
Laikipia
Jan.
Feb.
Mar.
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

FIG. 7

and assist with information, so that we may be able to utilize the knowledge gained to practical purpose. There is a possibility that in some districts one series of dippings against scab may be as effective as two half-yearly dippings; a slight modification in the times for shearing and dipping may make a world of difference and save considerable cash and labour.

Dipping

This problem also has received some attention during the last few years. The advantages and disadvantages of certain classes of dips have been discussed in practically every wool-producing country. Laboratory and field experiments have been carried out to determine the efficacy of home-made and proprietary brands. Opinions have been expressed in favour of certain compounds, but few, if any, have been able to show that any of the dips approved by Government are worthless.

In this country, arsenic and lime-sulphur compounds are used against sheep scab. It is generally acknowledged that it is inadvisable for the layman to manufacture the former on his farm. This is because there is an element of danger from poisoning to those engaged in its preparation.

Prompted by the conflicting statements on various dips used in Kenya, I examined the experiences of farmers and advisers in the important sheep farming countries, and published an article on "Sheep Scab: Remedial Measures Reviewed" in the *Bulletin of Entomological Research*, 1937.

It has not been possible to initiate an experiment on the relative value of dipping compounds, but a small preliminary trial with a proprietary brand of arsenic dip and lime-sulphur dip was carried out at the Government Farm, Naivasha.

The trial was outlined in order to determine whether it was possible to kill the scab mites on the sheep by either or both dips; whether it was practicable to carry out a strict system of hand-dressing, marking, counting and dipping the sheep three times at short intervals; and to observe the effect of the dip on the different groups of sheep, namely lambs, wethers, hoggets, rams, and native sheep.

The trial was incomplete and no conclusion could be drawn on the preventive qualities of dips used. It may be of interest, however, to deal very briefly with some observations made.

Both arsenic and lime-sulphur dips kill the mites with which they come into contact. Movement of sheep off the farm and to a locality where undipped sheep are pastured may be responsible for the reappearance of the disease when the flocks are again returned to the farm without further dipping.

Hand-dressing, involving the rubbing of the skin by hand, with lime-sulphur is painful and tends to blister the skin of the operators. Some less nocuous fluid should be used for this purpose. I may add that Downing has shown that the mites tend to migrate from places of concealment (the infra-orbital fossae, inguinal folds, the scrotum of the wether and possibly the tail) in the autumn, and thus become more accessible to dipping fluids. "Where large numbers of animals have to be treated, hand-dressing would entail an excessive amount of labour and expense, especially in hill flocks." While he does not actually commit himself on the question of hand-dressing under these circumstances, there is a suggestion, however faint, that if the time of dipping is nicely calculated, hand-dressing may not be so essential as when the mites are latent and hidden in inaccessible sites.

Marking the sheep to be dipped is an excellent safeguard against errors in counting and omissions to treat stray sheep or animals that have not previously been brought to the yards or pens for examination.

Unless closely supervised, natives tend to rough-handle the sheep as the latter enter the tank and when swimming in the dip. When sheep are thrown into the tank they sometimes swallow a considerable quantity of the fluid, and if they are not carefully manipulated in a straight-run bath they cut their legs against the sides or with their hooves. These cuts may provide access for arsenic or they may be sealed by a coating of lime-sulphur that prevents healing of the sore and leads to septic infection.

Moderately healthy sheep can withstand from two to four and a half minutes immersion in a properly mixed bath. Weak animals should be separated from those that are strong, dipped separately and assisted through the dip. Hoggets were observed to be more susceptible than wethers to the effects of immersion, and, surprisingly enough, hairy Masai sheep suffered more than woolled sheep. The majority of the sheep withstood immersion exceedingly well. The lime-sulphur seemed to have been harder on the sheep than the arsenic dip. The pungent odour of the former may have contributed to this.

The losses during and after dipping were small. Only 0.42 per cent was definitely attributable to the dipping. The sores, wounds and the results of "docking" lambs thus exposed to the toxic ingredients of the dips cannot justifiably be laid against the material used. Some of the sheep were weak and in very poor condition, while six lambs were starved.

Out of 1,200 sheep, 10 lambs and 8 adults died. Of these the ten lambs and one adult had been passed through the arsenic dip, and the other seven adults had been immersed in lime-sulphur.

After the first dipping, the mortality was 0.66 per cent, after the second 0.75 per cent, and after the third and last dipping 0.09 per cent.

The intervals between dippings in this case were nine days between the first and second and from ten to twelve days between the second and third.

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Planting Eucalyptus Trees

By C. D. HILL, *Rongai, Kenya Colony.*

In the drier areas difficulty is often experienced in the establishment of gum trees owing to the uncertainty of the rainfall and the sudden cessation of rains, with subsequent rapid desiccation. The necessity for tree planting in these areas for purposes of fuel, windbreaks, shade, etc., is very great, and the method described below constitutes a cheap and efficient means of securing a high percentage stand. It has been successfully applied to *Eucalyptus maculata* and *Eucalyptus citriodora.*

The area to be planted is pegged out in the usual manner in check rows at the required spacings and then four or five seeds are planted at each peg. The workers carry the seed in the left hand, and moistening a finger of the right hand apply it to the seed, which adheres. They remove the surplus with the thumb until four or five seeds remain. The finger with adhering seeds is then pressed into the soil rather less than a finger-breadth deep, and the depression filled. If the workers are allowed to take a pinch of seed between finger and thumb it is found that at least twenty seeds are taken, entailing great wastage. The planting of the seeds is followed immediately by laying grass over them, otherwise the sun would soon dry up the soil in contact with them. The seeds should break through between the twelfth and fourteenth day, when the grass is removed. Its end is knotted and pushed over the pegs of those that have germinated. Its loose ends are spread out to form a shade to protect the young seedlings from the sun or heavy storms. This is most important, since a heavy rainstorm can destroy the seedlings if they are not so protected. The grass is replaced flat on those that have not germinated, and these are examined again a few days later. After the twenty-first day any misses are replanted in a similar manner.

A stand of 80 to 90 per cent can be obtained in this manner, as compared with the 40 to 50 per cent stand often obtained in dry areas when attempts are made to transplant young seedlings. Moreover, this method obviates the expense and labour of seed beds, transplanting and pricking out, the cost of boxes, and the labour of transporting them to the field from the nursery.

A Planter's Experience with Coffee in the Trans Nzoia

By G. W. REYNOLDS, *Kitale, Kenya Colony*

Although it may be true of a large number of coffee planters in the Trans Nzoia that their interest in coffee waxes or wanes as the price of maize drops or rises, those who produce the bulk of the crop show an intense and progressive interest in all the current problems.

Two or three points stand out from past experiences as definite. The first is that clean weeding without very efficient anti-erosion measures, although it may give encouraging results as far as the growth of young trees is concerned, is a fatal method of cultivation; the second that the slashing of tall weeds in wet weather appears to encourage the growth of grass weeds, which are definitely harmful; the third, that although there is a period in the growth of shade trees when they do more damage in the dry weather by taking moisture from the ground than good by the shade they provide, yet later on when they grow larger the effect is reversed.

As far as present problems go the question of shade or no shade is not so controversial as it was. "Elgon die-back" has very largely seen to that, and most of us are now endeavouring to find the perfect shade tree since shade is found effective as a control. Whether *Grevillea robusta* will be ousted from its present position as premier shade tree remains to be seen. The writer feels that coffee looks and bears better under it than under any other shade tree, but if it is true, as experienced planters from other districts tell us, that after twenty years coffee does not do well under it, then it is a mistake to plant it. As far as I know there is no coffee in the Trans Nzoia that has been under *Grevillea* shade for that length of time. Quite a lot of us feel grateful to Mr. Nutman of Amani for his article on shade. It appears to explain certain points that were puzzling us, such as: why trees suffering from the yellowing and die-back said to be due to lack of carbohydrates were nearly always trees in the open and not under shade; why trees in the open, that were pruned and handled so as to open up their centres, often failed to bring their crop to maturity so well as those left with what an Eastern planter would call an excess of leaf in the centre; why coffee trees under shade generally blossom earlier than those in the open; and why, even if they blossom at the same time, the coffee under shade will ripen from three to four weeks earlier than that in the open.

Coffee Berry disease is still a major problem and in certain areas is so persistent that coffee growing is extremely unprofitable. In other areas, where the loss of crop is not so great, the more open growth of coffee on the multiple stem system seems to have lessened the annual loss; possibly this results from the better circulation of the air, or perhaps the entirely new growth that takes place from time to time on the multiple stem system has something to do with it. Elgon die-back is a serious problem on Mt. Elgon. Current investigations of the Department of Agriculture suggest that certain types of coffee found in most plantations are resistant to it and also that shade is quite effective as a control, even with non-resistant types. Unfortunately the variety that appears to be most resistant to Coffee Berry disease, namely Blue Mountain, is susceptible to Elgon die-back and its liability to Coffee Berry disease under shade in this district is not yet known. Whether Blue Mountain is going to become too open a tree under shade is not certain but some of us feel that the much

maligned Mysore, which may be moderately resistant to Coffee Berry disease, is capable of very different growth on multiple stem and under shade. Harar and the Trans Nzoia Series "A" type give a strong robust growth and catch the eye in that way. Whatever the outcome may be, there is plenty of interesting work ahead and co-operation with the Department of Agriculture should produce interesting results in the near future.

Thrips, which can cause more damage to a plantation in a given time than any other of our diseases or pests, becomes serious from time to time, but it is nowadays very noticeable that the damage done by Thrips to coffee growing under well regulated shade is not nearly so serious as to coffee growing in the open.

The question of weed control is an annual nightmare to many of us. Completely clean plantations properly protected against erosion with a liberal dressing of compost annually are probably the ideal, but they are very, very few and far between. In a normal year, when the rain is more or less continuous from March to November, weeds grow on every plantation and in the open, on rich soil, assume gigantic proportions. Hardly any of us seem to make use of the weeds by converting them into humus. Hand hoeing is not efficient when the soil is damp and the grass weeds always seem to be the ones that survive. The use of small ploughs worked with a rocking motion may be a quick method of making the ground look brownish instead of green, but they are not really efficient and on some of the shallower Elgon soils, where the coffee is older and the roots very much at the surface, they do great damage to roots on occasions. I feel there is room for improvement in the handling of our weed growth and some system whereby the tall weeds can be efficiently collected and buried in wet weather, such as box ridging or contour banking, would seem to be better than the usual practices. The growth of weeds under well regulated shade is much less aggressive than in the open and they are much more cheaply controlled.

Very few planters are easy in their minds as to whether to grow single or multiple stem and there are many "compromises" in practice. However it is significant that several of the more experienced planters, who have given multiple stem what they consider a fair trial, are changing to a topped multiple, to be pruned like a single. In the light of my experience, it would seem that a greater boldness in removing secondary growth would overcome many of the troubles that have arisen when the trees get tall. Whether, when we get better and more shade, multiple stem will come into greater favour again or not is doubtful. The problem of labour for pruning was one that had much influence on the original change from single to multiple, but the disappointing behaviour of the coffee grown on the tall trees and the inconvenience of harvesting were causes of the reversion to a kind of single stem. More and better shade will lessen the work of pruning single stem and may cause the growth of multiple stem to become excessively open and floppy.

Leaf-fall is becoming more pronounced as plantations get older. In the old days of single stem in the open we had such an abundance of leaves that the loss of a few was not noticed. Now, however, there is an increase in the spotty leaves that look as though they were going to break out with *Hemileia vastatrix* but never do. Instead they merely fall off and on open-growing coffee under shade the loss of each leaf is more important than of old. So far spraying does not seem to give

the spectacular results that occur at the Scott Laboratories, but there are signs that annual spraying is of benefit; though we probably do not yet know the correct months in which to spray. I know we should feel happier if someone discovered the cause of the spotty appearance of the leaves. Is it a sign that trees have a partial immunity to *Hemeleia* or is it a visible indication of some soil deficiency? Shade or no shade, the spotty leaves are there in the older plantations where they never used to be.

Soil problems are important in the Trans Nzoia. There are two main types of soil, the sandy soils of the "plains" and the "Elgon" soils. The sandy soils are light and easily eroded and somewhat lacking in reserves of humus. They are however deep and potentially useful soils. Contour cultivation is important to prevent erosion and liberal additions of organic matter from the start of cultivation are advisable to keep up the fertility of these soils. Given contour cultivation and more humus from the beginning, the sandy soils are capable of wonderful things. but either without the other is wasted.

The Elgon soils are often more shallow than the sandy ones, but the need for humus is not so great to begin with. However, the preservation of the top soil is of the utmost importance and, as the eastern side of Elgon does not suffer from the terrific downpours that are experienced in other parts of the country, effective anti-erosion measures, in addition to preserving the top soil, will ensure that every drop of water goes into the soil. The result is that the trees are less liable to suffer from a dry period which may continue from December to March inclusive.

Concerning manuring one hears many conflicting opinions. Wherever I have been invited to see plantations that have been "improved out of all knowledge by manure or mulching" it has been noticeable that the period of manuring or mulching has coincided with the arrival of the shade trees at a growth when they were really shading the coffee. Add to this the fact that I have seen plantations —including my own—where heavy manuring and fertilizing in the open over a period of years has produced no significant results, and I believe I am justified in thinking that in the Trans Nzoia the two—manuring and shading—should go hand in hand. As far as grass mulching is concerned, I have observed that a continuous grass mulch will greatly improve the sandy soils of the district, and on Elgon soils I find that a complete grass mulch from November to April, if sufficiently thick to keep off the rays of the sun, is of tremendous benefit to the growth of the trees. Whether it will on the whole pay better to convert the grass into good compost with the aid of fertilizers or apply it direct to the plantation, with fertilizers to help it rot down, has not yet been proved as far as I am aware. Co-operative experiments should go a long way to settle this point.

Although the Kitale experimental coffee plots may not receive the approval of a trained experimentalist, it must be borne in mind that they were laid down when money for that sort of work was almost non-existent; yet they have justified themselves in more ways than one, and for those who care to interpret what they see there, a few things stand out plainly. First it is quite obviously a mistake to plant quick-growing shade—such as *Sesbania*—until the coffee has been in the plantation for at least two years. Secondly the covering of the ground completely with a grass mulch when the coffee is planted, and renewing the mulch as required, produces a growth similar to that under light well-regulated shade;

under these conditions, although the coffee is in the open, the need for shade is not apparent for three or four years. As a third point, it is quite apparent that bush green manures—Crotalarias, etc.—do not suit young coffee. The plots act also as a very useful museum for types of coffee and varieties of shade trees, and their enlargement, benefiting from past experiences, will be of more and more value as fresh varieties become available.

It would be safe to say that in the Trans Nzoia, apart from soil fertility, most of our special problems are bound up with the climate. The majority of plantations in the Trans Nzoia were started with trees directly or indirectly from the old French Mission seed; but the climate of the Trans Nzoia has extremes of temperature too pronounced for many of the types that compose the French Mission variety. Coffee has often a pinched and stunted growth, ascribed to Hot and Cold disease and in certain localities Elgon die-back is prevalent. In the definitely colder and more humid places found in local depressions Coffee Berry disease is added to the other troubles connected with climate. The position in the climatically difficult areas is otherwise becoming more hopeful as a result of observation and experiments by farmers and the Department of Agriculture. These suggest that the general establishment of shade and the general use of only those types of coffee that are showing suitability to our climate should make things easier for the coffee planter in future.

Coffee planting in the Trans Nzoia is not usually the sole activity of the farmer, who is more often than not either a maize grower or stock farmer as well. The individual acreages under coffee are comparatively small and it should not be too difficult for the farmer to do what is necessary to improve the outlook for coffee growing. Resistant varieties are attracting great attention but so far we have not gone very far in the direction of planting them.

Reviews

A SWAHILI DICTIONARY OF PLANT NAMES, by P. J. Greenway, F.L.S. (Government Printer, Dar es Salaam; Sh. 3).

This is beyond question the book for which we have been waiting for years. Its 112 pages of closely packed information provide the man in the street at long last with a clue to the connexion between plant (botanically defined) and plant-name, the absence of which has been so baffling in the past.

There are many of us who live in Africa for some reason or other and pursue our daily avocations without possessing, or indeed needing to possess, any scientific botanical knowledge. As we are intelligent beings we take an interest in the world around us, and the plant world has so much to offer that is new to us that its attraction is immediate. It is true that if we live in a town, or if our contacts are mainly with town natives, our questions will so often meet with the rather contemptuous answer, *magugu* (weeds) or *maua tu* (just flowers), that we readily begin to imagine that the African has no interest whatever in anything but foodstuff; but if our life takes us into the country, we soon find that many a countryman knows the lore of the countryside, and that this is as extensive in Africa as in any country in the world.

Africa is, however, a large place, and the variations of tribal languages, and of local dialects within these languages, add enormously to the complexity of achieving more than the merest surface contact with native life. In the matter of listing the proper names of trees and plants this complexity probably reaches its apex. As Mr. Greenway so justly notes in his preface, "The native names of plants vary considerably in the same tribe, even from village to village." Anyone, therefore, who begins to collect these native names will soon find that he has a large number to deal with, and that many of them are not Swahili names; if, at the same time, he is unable to identify the actual plants by their universal botanical names, he soon becomes discouraged by the thought that he not only needs help in tabulating his results, but also lacks the means of making these results contribute to any useful purpose for the general run of mankind.

It is just here that the author's offer to act as a sort of general clearing-house for all the information which can be gathered is most encouraging. We feel emboldened to hope that this neat and scholarly pocket volume is an instalment; and that the success of this book will open the way for a larger Dictionary of Plant Names covering the Bantu languages of all Tanganyika, or of the whole of East Africa. This no doubt depends to a considerable extent on the measure of co-operation which is forthcoming from the interested amateur. A very large nucleus of such a Dictionary already exists at Amani, but many of the names in it are mere names, and need both verification and definite connexion with some particular locality or language. There can also be no doubt that correspondents all over the country may be able to make very extensive additions to this material. Much information remains to be gathered about the uses of various plants, and in this connexion anyone may at any time stumble upon a discovery, which through the chemist may eventually become as great a boon to the world as quinine.

Some people think that a dictionary is the dullest book in the world; others find it a never-ending source of interest. Whichever may be our attitude, we all know what a dictionary is for, and that there are times when we cannot do without it. Your reviewer feels that his judg-

ment is sufficiently indicated when he says that this book certainly possesses the indispensable character of a dictionary, that it is admirably arranged, and that it fulfils its purpose. Several people to whom he has already introduced it have almost immediately turned rather wistfully to the end and remarked that there is no index. That is true, but we cannot expect two dictionaries for the price of one, even if they are bound in the same volume, and the initial difficulty of the cost of production had to be considered. Neither governments nor private individuals can afford to print all that they would wish to print, without any reference to the possible market for such productions.

We must therefore hope that the sales of this book will resolve all doubts as to the financial possibility of such a larger dictionary as has been suggested; and though it may seem greedy to ask for more when the author has given us a feast, it is none the less a compliment, for it shows that the food is good. Our sincere gratitude to the author is accompanied as always by "a lively sense of further favours to come."

A. B. H.

FOREST BIBLIOGRPHY TO 31ST DECEMBER, 1933; Part I, 5/-; Part II, 12/-. (The Department of Forest, University of Oxford, 1937.)

This bibliography, which "comprises a fairly complete list of papers, bulletins and other matter published in English and a considerable amount of literature published in French and German," can have few rivals in the magnitude of its scope, and certainly none within the field of agriculture and allied subjects. The classification that forms the basis of the bibliography is primarily under sixteen heads. The two parts, between them two hundred pages, now noticed deal only with the first two heads; so although one of those, Silviculture, is probably one of the biggest, the probable bulk of the whole bibliography can be guessed at over a thousand pages. The references, arranged within the subdivisions by years, are well adapted for ready reference. It is clear that no one concerned with the literature of forestry can work without this compilation; and almost wherever he may be the immediate effect of it will be dissatisfaction with local library resources.

Factors Affecting the Attacks of Sucking Insects on Cotton

By A. M. GWYNN, *B.Sc., Entomologist, Department of Agriculture, Uganda Protectorate*

It is often convenient to distinguish between insect pests with biting mouth-parts (locusts, caterpillars, beetles, etc.) and those with sucking mouth-parts (Thrips, and the many divisions of the Hemiptera, such as Aphids, scales, Capsid bugs, etc.). The cotton crop is attacked by a large variety of pests of both groups, but in the present article attention is confined to the latter. In a sense the biting insects are more straightforward to deal with, since the result of their feeding is usually obvious; the amount of damage done is correspondingly easy to assess, and often their activities are little affected by the health of the plant. On the other hand, with sucking insects it is frequently necessary to do experiments to determine the effect of their feeding; it is usually difficult to assess even roughly the amount of damage they cause, and any estimate of loss is almost bound to be speculative and open to controversy; finally, they may be much influenced by the health of their host plants, so that it is nearly always a matter for argument whether they are doing any damage at all.

It is sometimes maintained that the presence of sucking insects is always a symptom of ill-health in a crop, and that any loss incurred is in fact due to the ill-health of the plants, or at least that the only way to reduce insect damage is to improve the health of the plants.[1] In answer to this it may be said that. while the health of the plant undoubtedly influences the degree of insect attack in many cases, it is by no means the only factor involved; that, even where the degree of insect attack is largely governed by factors operating through their effect on the health of the plant, the pests concerned often cause severe damage to crops which would otherwise have produced fair yields in spite of somewhat adverse conditions; and lastly that it is frequently easier to control such pests by direct methods than by treating the plants.

It is worth examining the effect of plant health on insect attack in some detail. The first point which arises is whether the health of the plant affects the insects feeding on it as much as is often made out. Often the severity of insect attack may be correlated with poor soil, water-logging, or other unfavourable factors which would be reflected in yield, even in the absence of insects. Here it seems legitimate to say that the health of the plant does influence the amount of insect attack. On the other hand there are cases where the extent of insect attack may be correlated with other factors, such as varietal susceptibility, climate, or other ecological circumstances, which may not be connected with the health of the plant. Examples of both sorts are discussed below, under the individual pests.

Secondly, it is necessary to distinguish between the effect of climate and weather, and the effect of plant health, on the insect population. It is of course obvious that climate has a profound effect on the health of the plant. At the same time it has an equally great effect on insect population, having a direct influence on the activities of the insects, on their reproduction, on their natural enemies, and

[1] This article was written before the writer had seen the Editorial of the March number of this Journal, but after reading Sir Albert Howard's paper and the reply to it by Bebbington and Allan.

influencing them indirectly through the plant. The direct influences have by definition nothing to do with the health of the plant; even the last does not necessarily imply a connexion between ill-health and insect abundance. Favourable weather conditions, promoting normal growth, may also favour certain pests by producing an abundance of suitable food. Unfavourable conditions may exercise an adverse effect on both plant and insects. An example of this is provided by Jassids, which are usually favoured by dry weather; but when cotton plants are suffering from a deficiency of moisture sufficient to cause the leaves to droop, the Jassid population immediately declines.

Then there is the question of succulence. It is frequently pointed out by those who emphasize the effect of plant health on insect attack that succulence or rapid growth is not necessarily a sign of good health. But is it necessarily a sign of ill-health? It is understandable that insects should prefer succulent tissues to dry woody tissues, but it does not follow from this that the succulent tissues are unhealthy; if a plant is to produce a crop it must grow, and when a plant is making active growth it is bound to be rather succulent. Admittedly certain varieties of cotton always tend to be more succulent than others and for this reason tend to suffer more severely from insect attack, but this does not necessarily mean that they are in any general sense less healthy than the less succulent varieties. However, in cotton it does seem to be true that those varieties which are more succulent and more susceptible to insect attack are not very hardy; and the hardier varieties are in fact resistant to many forms of insect attack. This point is further discussed under "Varietal Resistance".

A question which arises from the foregoing discussion is what actually constitutes a healthy plant. It might be said that any plant suffering from disease or insect attack, or making poor growth, is unhealthy; but this is begging the question under discussion, namely to what extent insect attack is *influenced* by the health of the plant. The writer would suggest that in this connexion the inherent health of a plant should be judged by the crop it would produce in the absence of insect attack or other specific disease. Where insect attack cannot be correlated with some factor or factors which would have an effect on yield in the absence of insects, it cannot be said that insect attack is a result of unhealthy conditions.

Before leaving the subject it may be mentioned that small stunted plants are often very free from insect pests (which prefer the better grown plants), but at the same time they do not produce any crop.

Varietal Resistance

Among different varieties of cotton great variations in degree of resistance to Jassids are well known; marked variations in resistance or susceptibility to other pests (e.g. *Helopeltis*) have also been demonstrated; and it is probable that careful study would show the existence of similar if less striking differences with regard to many other pests. It is sometimes maintained that these differences are merely a reflection of the "health" of the different varieties. There is a certain amount of truth in this, but it is a very inadequate picture of varietal resistance. With Jassids resistance is associated with hairiness; but whether there is a direct connexion—e.g. hairiness might deter the females from ovipositing—or whether it is merely a coincidence that hairiness is associated with some other factor responsible for the resistance of the plants, is not clear. Glabrous varieties, susceptible to Jassid attack, all seem to be somewhat lacking in hardiness; but other varieties

equally lacking in hardiness showed marked resistance to Jassid attack. From this it appears that while hardy varieties are resistant to Jassid, hairiness and resistance to Jassid are not always a criterion of hardiness. The case of *Helopeltis* is similar; here, susceptibility to *Helopeltis* attack shows a tendency to be associated with succulence, and secondarily, perhaps, with lack of hardiness. That is to say, succulent varieties lacking in hardiness, show most *Helopeltis*; less succulent varieties, though no more hardy than the first, show less *Helopeltis*; and hardy varieties show least of all. It should be noted that varieties which are resistant to Jassid may show marked susceptibility to *Helopeltis,* and that some varieties showing little susceptibility to *Helopeltis* are not markedly resistant to Jassid, while yet other varieties are very susceptible to both. In general hardy varieties are resistant to insect attack, while susceptibility to insect attack is an indication of lack of hardiness, but resistance to any particular pest is no criterion of hardiness. This is because the degree of resistance to a pest, while in part an expression of the hardiness of the variety concerned, is often ultimately determined by factors which may have no connexion with its hardiness.

It may be asked, what then is the use of studying varietal resistance? Why not select for hardiness and be done with it? The answer to this is first, that a knowledge of the reaction of any particular variety to its pests helps in forming an opinion on it; and second, that the objects of cotton breeding are quality and yield, and the final result is a compromise, namely the best quality cotton which will yield well under the circumstances in which it is to be grown. In arriving at this compromise it is probably necessary to sacrifice a little in quality, a little in yield, and a little in hardiness; and in doing this it is helpful to know as much as possible about the relative resistance or susceptibility of varieties to their sundry pests and diseases.

An interesting example of environment affecting insects through their host plants is afforded by the effect of environment on varietal resistance to Jassid. Generally the relative resistance to Jassids of different varieties of cotton remains constant in a wide range of environments. However, certain varieties seem to be relatively resistant to Jassid in some localities, while they are relatively susceptible, when compared with the same standard varieties elsewhere.

So far we have considered environment and varietal resistance solely in relation to their influence on the size of insect population. There are almost certainly variations in tolerance to insect populations of any particular size between varieties, and between plots of the same variety in different environments. However, little is known about this, and it is probably of secondary importance to the size of population present.

Insect Pests of Cotton

It now remains to consider the principal sucking pests of cotton in the light of the foregoing discussion.

1. *Cotton Stainers* (*Dysdercus* spp.).—These are in a rather different category from the other species to be considered, owing to their feeding habits and the nature of the damage they inflict. Feeding almost exclusively on the seed (ripe and unripe) of their host, they are apparently unaffected by the variety or by the health of the cotton. The principal controlling factors which determine their abundance on cotton are climate, which has a great effect on their reproduction (in very dry weather breeding practically ceases); the abundance and condition of their wild food-plants, which in turn is also governed

by climate and weather; and their natural enemies. Damage is mainly due to the boll-rot infections carried from boll to boll. It is said that their infectivity is directly decreased by dry weather, which may thus influence the damage they do, independently of its influence on their abundance. However, this needs confirmation, since the chance of a Stainer becoming contaminated with this infection naturally varies with the amount of boll-rot present, which is in turn dependent on the number of Stainers. As dry weather tends to keep the Stainer population at a low level, it also tends to keep down the percentage of contaminated Stainers, and thus to reduce the average infectivity of the population as a whole.

2. *Lygus*.—This pest is little, if at all, affected by variety, and it is uncertain to what extent it is affected by the health of the plant. In districts where *Lygus* is abundant, it occurs very generally, and there is little evidence that growing conditions have any appreciable influence on it, except that by the nature of its habits *Lygus* prefers plants making active growth. It shelters among the terminal buds, on which it feeds, and a check in growth reduces the amount of food and shelter in such situations. This is probably one reason why it seldom does much damage to undersized plants making poor growth. It has an alternative habitat under the bracts of buds and young bolls, on which it also feeds, but it is not certain to what extent this can compensate for reduction in shelter elsewhere. *Lygus* infestation always declines during the latter part of the season. This is no doubt partly due to changes in the plants as they get older, but other factors may also be concerned, since later sown cotton suffers relatively little from *Lygus* at any stage in its growth. *Lygus* differs from most pests in that after the initial invasion of the crop, the total adult population shows little tendency to increase; a certain amount of breeding takes place, but this is apparently insufficient to do much more than replace losses.

3. *Helopeltis*.—Unlike the preceding two pests, this insect is very sensitive to differences in variety and to plant health. It is further characterized by the great irregularity of its occurrence. In some years it appears to be completely absent from some districts, while in other years it may be widespread in the same districts; also, in any area in which it occurs its incidence is very capricious: some plots may be completely free, while others close by may be very heavily infested. The variations from season to season seem to denote great sensitivity to climatic conditions; this may also be one explanation of the sudden way in which infestations often begin and end. Variations in incidence from plot to plot can usually be correlated with conditions of growth, severe *Helopeltis* attack being commonly associated with poor soil, or with conditions unfavourable to proper root development, such as water-logging or the existence of a pan. In fact *Helopeltis* is an excellent example of the influence of plant health on insect attack. The insect also shows a marked preference for certain varieties; varietal susceptibility has been little studied, but it seems that *Helopeltis* tends to attack the more succulent varieties. This might be expected from its feeding and egg-laying habits [1]. It so happens that the more succulent varieties are not very hardy; but susceptibility is not simply a matter of the "health" of the variety, for varieties which are less succulent than the most susceptible varieties, but which cannot be considered any "healthier", are less heavily infested by *Helopeltis*.

It may be mentioned that varietal resistance to Jassid is not altogether similar

to varietal resistance to *Helopeltis*, since the most Jassid resistant varieties show almost complete immunity from this pest, while all varieties may suffer severely from *Helopeltis*, but some much more than others. It is as if Jassids are repelled by certain varieties, while *Helopeltis* is attracted to certain varieties more than to others. Thus it is here perhaps better to speak of degrees of susceptibility rather than of resistance.

4. *Jassid.*—This pest has been more fully investigated than most from the point of view of the effect on it of variety and plant health. It is much affected by variety and to some extent by plant health, but in Uganda both these factors are overshadowed by climate. Climatic conditions in this country do not normally permit Jassids to multiply to a point where they do appreciable damage. Partly, no doubt, for this reason, we have little data on the influence of plant health on this insect, although it certainly has an effect. Of more importance is the effect of variety; it is possible to get cotton varieties which show a very high degree of resistance to Jassids in any circumstances under which cotton will produce a crop. Though the hardier varieties are resistant to Jassid, the evidence indicates that Jassid resistance is ultimately determined by factors unconnected with hardiness.

5. *Aphid.*—Aphids tend to be more numerous in dry weather, and are probably considerably influenced by the health of the plant, but they are normally kept in control by the numerous predators and parasites which attack them. This is a case where the effects of climate and of plant health are of secondary importance, since nearly all cotton would be swamped by this pest but for its natural enemies.

An interesting illustration of this is given in the latest report of the Empire Cotton Growing Corporation's station at Barberton [2]. Patches of poor growth in a field of cotton had been found to be associated with heavy Aphid infestation; cotton was grown in this field for two years running, and a record of the location of these patches of poor growth kept. It was found that they did not coincide for the two years, but that in the centre of each patch was a colony of black ants, which tended the aphids and drove off their enemies. This plainly indicates that these patches of infestation were independent of soil conditions or similar factors, and were simply due to the protection afforded to the Aphids.

Conclusion

The question whether the attacks of any particular pest can be correlated with some factor influencing plant health, and hence whether the pest can be treated through the plant, should always be borne in mind; but in general the incidence of pests is determined by the interaction of a large number of more or less independent factors, of which plant health is only one; others are climate, varietal resistance, natural enemies, etc.

In field observations it is impossible to disentangle satisfactorily the effect of the health of the plant from other factors; for this reason the questions arising out of the affect of climate and of plant health on insect abundance cannot be finally settled without detailed experiments under completely controlled conditions. Such experiments are for the present, perhaps, outside the province of the economic entomologist, because the answers we can get from field observations and experiments, though imperfect, are sufficient as a working basis.

References

[1] Harris, W. V.: "Helopeltis Bug," *East African Agricultural Journal*, March, 1937, pp. 387-390.

[2] E.C.G.C., Reports from Experiment Station, 1935-36, p. 16.

Annotated Host List of Uganda Parasitic Fungi and Plant Diseases—Part V

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MONOCOTYLEDONES.

COMMELINACEAE.

COMMELINA sp. (Indigenous).
Uromyces commelinae Cke., rust.
? *Zythia nectriola* Speg., yellow to brown-red spots on lower surface of leaves.
Bacterium sp., leaf spot.

BROMELIACEAE.

ANANAS sp. (Arghan Fibre).
Peronospora sp., mildew, causing rotting of leaf bases.
Phyllosticta sp., leaf spot.

ANANAS SATIVA (Pineapple).
Thielaviopsis paradoxa (de Seynes) von Hohnel, conidial stage of *Ceratostomella paradoxa* Dade, rot of fruit; rare.

MUSACEAE.

MUSA sp. (Bananas and Plantains).
Marasmus semiustus B. & C., stem rot, associated with poor cultivation and excessive grass and weed cover, leading to very moist conditions around the base of the plants.
Gloeosporium musarum Cke. & Mass., ripe rot of fruit.
Thielaviopsis paradoxa (de Seyn.) von Hohnel, fruit rot.
Pestalozzia sp., on leaves.
Zygosporium oscheoides Berk., common on old leaves.
Helminthosporium musae-sapientum Hansford, leaf spot; possibly the same as the "macrospores" of *H. gibberosporum* Curzi, described from Somaliland.
Helminthosporium torulosum (Syd.) Ashby, fruit rot.
Cercospora musae Zimm., leaf spot.

ZINGIBERACEAE.

AFRAMOMUM sp. (Indigenous).
Gibberidea zingiberacearum Rac.
Uredo aframomi Har. & Pat., rust.

CANNACEAE.

CANNA sp. (Cultivated).
Fusarium sporotrichioides Sherb., rot of flower buds.

LILIACEAE.

ALLIUM CEPA (Onion).
Puccinia allii Rud., rust.

ASPARAGUS sp. (Indigenous).
Puccinia asparagi DC., rust.

ALOE sp. (Indigenous).
Uromyces aloes (Cke.) Magn., rust.
Phoma aloicola Trinch., leaf spot.
Phyllosticta sp., leaf spot.
Pestalozzia sp., leaf spot.

DRACAENA UGANDENSIS (Indigenous).
Meliola dracaenicola Pat. & Har., on leaves and young stems.
Phyllosticta sp., leaf spot.

GLORIOSA sp. (Indigenous).
Colletotrichum sp., and
Cercospora sp., on leaves.

ORNITHOGALUM sp. (Indigeous).
Ustilago peglerae Bub. & Syd., smut of anthers.

PHORMIUM TENAX (New Zealand Flax).
Pestalozzia sp., leaf spot.
Heterosporium sp., brown mould over lower leaf surface.
Mycosphaerella sp., leaf spot.

SANSEVIERIA sp. (Indigenous.
Meliola sansevieriae Wakef., on leaves

SMILACACEAE.

SMILAX KRAUSSIANA (Indigenous).
Puccinia kraussiana Cooke, rust.

ARACEAE.

AMORPHOPHALLUS sp. (Indigenous).
Cercospora chevalieri Sacc., leaf spot.

IRIDACEAE.

DIERAMA sp. (Indigenous).
Puccinia dieramae Syd., rust.

GLADIOLUS QUARTINIANUS (Indigenous).
Uromyces gladiolii P. Henn., rust.
Uromyces transversalis (Thum.) Wint., rust.

Alternaria tenuis Bolle, f., leaf spot.
Fusarium sporotrichioides Sherb., rot of flower buds.

DIOSCOREACEAE.

DIOSCOREA sp. (Indigenous).
Amazonia dioscoreae Hansford & Stevens.
Asterina sp.
Hemileia dioscoreae-aculeatae Rac., rust.
Uredo dioscoreae P. Henn., rust.
Phyllosticta sp., leaf spot.
Cercospora dioscoreae E. & M., leaf spot.

AGAVACEAE.

AGAVE SISALANA (Sisal).
Colletotrichum agaves Cav., leaf spot.

PALMAE.

CARYOTA URENS.
Sphaeronema fimbriatum (E. & H.) Sacc., on trunk.

PHOENIX RECLINATA (Indigenous).
Meliola palmicola Wint., on leaves.
Gibbera guaranitica Speg.
Lophiostoma juliis var. *phoenicis* Roll.
Phyllachora sp., on leaves.
Graphiola phoenicis (Moug.) Poit., on leaves.

PHOENIX DACTYLIFERA (Date Palm).
Meliola palmicola Wint., on leaves.
Graphiola phoenicis (Moug.) Poit., leaf spot.

RAPHIA MONBUTTORUM (Indigenous).
Meliola palmicola Wint., on leaves.

HYPOXIDACEAE.

HYPOXIS sp. (Indigenous).
Uromyces hypoxidis Cooke, rust.

ORCHIDACEAE.

VANILLA PLANIFOLIA (Vanilla).
Colletotrichum sp., leaf spot.

CYPERACEAE.

CYPERUS sp. (Indigenous).
Cintractia limitata Clint. (prox.), smut.
Uredo cypericola P. Henn., rust.

FIMBRISTYLIS sp. (Indigenous).
Puccinia fimbristylidis Arth., rust.

KYLLINGA sp.
Uredo kyllingae P. Henn., rust.
Helminthosporium kyllingae Hansford, on inflorescence.

MARISCUS sp. (Indigenous).
Phyllachora cyperina P. Henn., on leaves.
Puccinia hennopsiana Doidge, rust.
Cintractia axicola (Berk.) Cornu., smut.
Piricularia (? *grisea* Sacc., f.), leaf spot.

SCLERIA HIRTELLA (Indigenous).
Puccinia sp., rust.

GRAMINEAE.

AMPHILOPHIS INSCULPTA.
Uredo sp., rust.

ANDROPOGON sp.
Uromyces clignyi Pat. & Har., rust on *A. abyssinicus.*
Uredo sp., on *A. dummeri.*
Ustilago ischaemi Fckl., smut.
Fusarium graminearum Schwabe, conidial stage of *Gibberella saubinetii* (Mont.) Sacc., on culms.

ARISTIDA sp.
Puccinia lomellii Wakef. & Hansf., on *A. lomellii.*
? *Puccinia eylesii* Doidge.
Uredo sp. on *A. adscenzionis.*

ARTHRAXON sp.
Uredo arthraxonis-ciliaris P. Henn.,rust.

BAMBOOS (Indigenous).
Engleromyces goetzei Henn.

BRACHIARIA sp.
Phaeodothis stenostoma (Ell. & Tr.) Th. and Syd., on leaves.
Uromyces leptodermus Syd., rust.
Diorchidium brachiarae Hansford, rust.
Helminthosporium sp.
Cercospora sp., leaf spot, common on *B. brizantha.*
Beniowskia sphaeroidea (Cke.) Mason, leaf spot.
Fusarium heterosporum Nees, on seeds.

CHLORIS sp.
Phyllachora chloridicola Speg.
Uromyces chloridis Doidge, on *C. breviseta, C. virgata,* and *C. myriostachya,* all from Karamoja.
Puccinia chloridis Speg., on *C. pycnothrix.*
Uredo sp.
Helminthosporium sp., leaf spot.

CTENIUM sp.
Uredo ctenii Wakef. & Hansf., rust.

CYMBOPOGON sp.
Phyllachora sp.
Puccinia cymbopogonis Mass., on *C. citratus.*
Puccinia erythraeensis Pas.
Puccinia sp. nov.

Colletotrichum graminicolum (Ces.) Wils., leaf spot.
Polythrincium sp., leaf spot.
Helminthosporium sp., leaf spot.

CYNODON sp.
Phyllachora cynodontis (Sass.) Niessl., black leaf spot.
Puccinia cynodontis Desm., rust.
Ustilago cynodontis (P. Henn.) Bref., smut.
Helminthosporium cynodontis Marign., leaf spot.
Cerebella cynodontis Syd., false smut.
Fusarium heterosporum Nees, pink fungus on *Ustilago* and on seeds.

DACTYLOCTENIUM AEGYPTIACUM.
Uromyces dactyloctenii Wakef. & Hansf.,

DIGITARIA sp.
Phyllachora sp.
Claviceps digitariae Hansford, ergot of *D. scalarum.*
Ustilago digitariae Rabh., smut.
Piricularia grisea Sacc., f., leaf spot.
Piricularia oryzae Cav., f., transmissible to *Eleusine coracana.*
Helminthosporium sp.
Cercospora sp.
Uromyces peglerae Pole Evans, rust.
Puccinia digitariae Pole Evans, rust.

ELEUSINE CORACANA ("Bulo").
Phyllachora eleusines Speg., black spots on leaves.
Cylindrosporium sp., leaf spot.
Piricularia oryzae Cav., f., "blast" disease, causing leaf spot, foot rot, stem lesions, ear lesions; the most important disease of this crop in Uganda.
Helminthosporium leucostylum Drechsler, attacks leaves, stems, and heads in a manner similar to *Piricularia.*
Helminthosporium nodulosum B. & Curt., similarly attacks all parts of the plant.
Sclerotium rolfsii Sacc., root disease; rare on this crop.
Gibberella saubinetii (Mont.) Sacc., foot rot, chiefly on plants growing on poor soil.

ELEUSINE INDICA (Wild Grass).
Phyllachora eleusines Speg.
Helminthosporium leucostylum Drechs.

ENTEROPOGON sp.
Septoria sp., leaf spot.

ERAGROSTIS sp.
Phyllachora sp.
Uromyces eragrostidis Tracy, rust.
Helminthosporium ravenelii Curt., on inflorescence.

EXOTHECA sp.
Uredo exothecae Wakef. & Hansf., rust.
Hendersonia crastophila Sacc., f.

HETEROPOGON sp.
Puccinia erythraeensis Pazschke, rust.

HYPARRHENIA sp.
Didymosphaeria sp., on dying culms.
Leptosphaeria sp., on dying culms.
Ophiobolus implexum (E. & E.) Berl., prox., on culms.
Lophiostoma hyparrheniae Hansford, on culms.
Sphacelotheca congensis (Syd.) Wakef., smut.
Sorosporium tembuti Ev. & Henn., smut.
Puccinia erythraeensis Pazschke, rust.
Hendersonia sacchari Speg., prox., on culms.
Helminthosporium hyparrheniae Hansford, leaf spot.
Tetraploa aristata B. & Br., dying culms.
Cercospora sp., leaf spots.

IMPERATA CYLINDRICA.
Monacrosporium sp., leaf spot.
Puccinia rufipes, Diet., rust.
Ustilago schweinfurthiana Thum., smut.

ISCHAEMUM sp.
Phyllachora liebenbergii Hansford.

LEERSIA sp.
Dimeriella (? *Olyrae* Stevens).
Testicularia leersiae Cornu, smut.

LEPTOCHLOA sp.
Phyllachora cynodontis (Sacc.) Niessl.
Uromyces leptochloae Wakef., rust.

MELINIS MINUTIFLORA.
Uredo sp., indet., rust.

MICROCHLOA sp.
Uromyces microchloae Syd.

MISCANTHIDIUM sp.
Phyllachora sp.
Uredo sp., indet., rust.

OLYRA sp.
Dimeriella olyrae Stev.
Puccinia deformata B. & C., rust.

ORYZA SATIVA (Rice).
Leptosphaeria iwamotii Miy., leaf spot.
Leptosphaeria michotii (West.) Sacc., leaf spot.
Ophiobolus miyabeanus Ito & Kurib., conidial stage *Helminthosporium oryzae* Miy., leaf spot.

Gibberella saubinetii (Mont.) Sacc., conidial stage *Fusarium graminearum* Schwabe, foot rot, also on ears.
Phoma glumarum Ell. & Tr., on ears.
Piricularia oryzae Cav., "blast disease," has proved a limiting factor to the development of this crop in Uganda; at times serious losses have been experienced; the disease attacks all parts of the plants, but frequently only the heads are affected and the disease remains unnoticed until harvest, when the ears are found to be empty or only partially filled. It is not certain whether the rice strain is transmissible to *Eleusine*.
Common saprophytes on the ears and stubble are:—
Graphium stilboideum Cda.,
Epicoccum sp.,
Melanospora zamiae Cda.,
Nigrospora sp., and
Fusarium moniliforme Sheld.

PANICUM sp.
Phyllachora graminis (Pers.) Fckl.
Phyllachora heterospora P. Henn.
Uromyces leptodermus Syd., rust.
Ustilago heterospora P. Henn., smut.
Ustilago ugandensis P. Henn., smut.
Piricularia grisea Sacc., ff., leaf spots.
Helminthosporium panici van Overeem.
Fusarium heterosporum Nees, on sori of *Ustilago*.
Fusarium moniliforme Sheld., on *Ustilago*.

PASPALUM sp.
Uredo paspali-scrobiculati Syd.

PENNISETUM PURPUREUM (Elephant Grass).
Ustilago kamerunensis Syd.
Coniosporium inquinans Dur. & Mont.
Helminthosporium sp., leaf spots.
Tetraploa aristata B. & Br., on moribund tissues.
Speira sp., on dead culms.
Xenosporella berkleyi Sacc., on dead culms.
Beniowskia sphaeroidea (Cke.) Mason, leaf spot.
Sphacelia sp., on culms; no ascus stage has yet been found.
Piriculia grisea Sacc., f., leaf spot.
Phyllachora penniseti Syd., on leaves.
On dead culms the following have also been recorded:—
Trichosphaeria bambusina v. Hohn. (prox.),
Didymosphaeria panici March. and Stey.,
Leptosphaeria penniseti Hansford,
Ophioceras bambusae v. Hohn.,
Pestalozzia sp.,
Didymopsis sp.

PENNISETUM TYPHOIDES (Bulrush Millet).
Phyllachora penniseti Syd., on leaves.
Sclerospora graminicola (Sacc.) Schrot., "green ear disease"; the heads may be either wholly or in part converted into a mass of small leafy outgrowths, which replace the grain.
Sphacelia sp.
Cerebella sorghi-vulgaris Subram.
Puccinia penniseti Zimm., rust; often severe.

PENNISETUM (Other Wild Species).
Phyllachora penniseti Syd.
Uredo of *Puccinia penniseti* on *P. clandestinum*.
Uredo sp. (nov.?) on *P. clandestinum* and *P. polystachyum*.
Chaetostroma atrum Sacc.

PEROTIS sp.
Helminthosporium sp., leaf spot.

RHYNCHELYTRUM REPENS.
Phyllachora tricholaenae P. Henn.
Diorchidium tricholaenae Syd., rust.
Piricularia grisea Sacc., f., leaf spot.

ROTTBOELLIA EXALTATA.
Puccinia rottboelliae Syd., rust.
Cercosporella rottboelliae Hansford, leaf spot.

SACCHARUM OFFICINARUM (Sugar Cane).
Leptosphaeria sacchari Breda d. Haan, leaf spot; not important as a disease in Uganda.
Melanconium saccharinum Penz. & Sacc., probably saprophytic.
Melanconium sacchari Mass., chiefly on old stalks.
Nigrospora oryzae (B. & Br.) Petch, probably only saprophytic.
Acrothecium lunatum Wakker, common on old leaves and sheaths.
Helminthosporium sacchari Butl., leaf spot.
Stigmella sacchari Speg.
Cercospora longipes Butl., leaf spot; especially common on Uba, Co.281 and Co.290; apparently does little damage.
Cercospora kopkei Krug.
Colletotrichum falcatum Went., "red rot"; uncommon in Uganda.

Sclerotium rolfsii Sacc., root disease, uncommon on this host.
Thielaviopsis paradoxa (de Seyn.) von Hohnel, uncommon.
Marasmius sacchari Wakker, "root disease," limited to odd stools and not important in Uganda.
Mosaic Disease. Of less importance in recent years in Uganda, as the varieties now grown are commercially resistant to infection.
Bacterium rubrilineans Lee *et al.*, "red stripe," a disease of young canes, somewhat retarding their rate of growth; older canes appear to recover from its egect; effect on yield appears to be slight. P.O.J. 2727 is the most susceptible of our standard cane varieties at present.

SCHIZACHRYIUM sp.
Epichloe schumanniana P. Henn.

SETARIA sp.
Sclerospora graminicola (Sacc.) Schrot., downy mildew of *S. verticillata.*
Phyllachora evansii Syd., H. & P., var. *macrospora* Hansford.
Puccinia cameliae Arth., rust.
Puccinia kigeziensis Wakef. & Hansford, rust.
Puccinia setariae-longisetae Wakef. and Hansford, rust.
Ustilago heterospora P. Henn., rust.
Helminthosporium sp.
Uredo sp., rust on *S. aequalis.*
Uredo sp., rust on *S. rubiginosa.*
Uromyces setariae-italicae (Diet.) Yosh., rust.
Piricularia sp. (nov.?), leaf spot.
Hendersonia sp., on culms.
Fusarium heterosporum Nees, on sori of *Ustilago.*

SORGHUM VULGARE (Guinea Corn).
Sclerospora graminicola (Sacc.) Schrot., on occasional plants.
Sclerospora sorghi (Kulk.) Weston and Uppal.
Puccinia purpurea Cooke, rust.
Sphacelotheca sorghi (Lk.) Clint., smut, common, and occasionally causes considerable losses.
Sphacelotheca cruenta (Kuhn) Pott., loose smut, uncommon.
Sorosporium reilianum (Kuhn) Clint., rare.
Phoma insidiosa Tassi.
Colletotrichum graminicolum (Ces.) Wils., leaf spot.
Nigrospora sphaerica Sacc., on leaves; probably saprophytic.
Helminthosporium turcicum Pass., leaf disease; large areas of the leaves turn greyish and papery; usually limited to the older leaves, when the effect on yield is small.
Cercospora sorghi E. & Ev., leaf spot.
Acrothecium lunatum Wakker, leaf spot.
Fusarium heterosporum Nees, on smutted heads.
Fusarium moniliforme Sheld., on smutted heads and on dying tissues.
Cerebella andropogonis Ces., false smut.
Cerebella sorghi-vulgaris Subram., false smut.
Rhizoctonia bataticola (Taub.) Butl., on roots; uncommon.

SORGHUM (Wild Species).
Puccinia purpurea Cooke, rust.
Sphacelotheca sorghi (Lk.) Clint., smut.
Microdiplodia sp., on leaves.
Clasterosporium maydicum Sacc., on leaves.
Alternaria tenuis Bolle, f., on leaves and stems.
Cercospora (*kopkei* Krug. ?), on leaves.
Chaetostroma atrum Sacc., on dying tissues.
Cerebella andropogonis Ces., false smut.

SPOROBOLUS sp.
Phyllachora cynodontis (Sacc.) Niessl.
Uromyces tenuicutis McAlp., rust.
Puccinia liebenbergii Wakef. & Hansf., rust, on *S. filipes.*
Helminthosporium ravenelii Curt., on inflorescence.

THEMEDA sp.
Uredo anthistiriae-tremulae Petch., rust.
Sorosporium holstei P. Henn.

TRAGUS sp.
Uromyces tragi Hansford, rust.

TRICHOPTERYX sp. (including *Loudetia* sp.).
Leptosphaeria trichopterygis Hansford, on *T. afroflammida.*
Epichloe cinerea B. & Br.
Ustilaginoidea trichopterygis Wakef.
Puccinia erythraeensis Pazschke, rust on *T. kagerensis.*
Puccinia trichopterygis Wakef. & Hansf., on *T. afroflammida* and *T. arundinacea.*
Tetraploa aristata B. & Br., on dying parts.

TRITICUM VULGARE (Wheat).

Leptosphaeria tritici (Garov.) Pass., leaf spot.

Ophiobolus sativus (P. K. & B.) Ito and Kurib., conidial stage *Helminthosporium sorokinianum* Sacc., leaf spot and foot rot.

Gibberella saubinetii (Mont.) Sacc., conidial stage *Fusarium graminearum* Schwabe, foot rot and grain disease.

Puccinia glumarum (Schm.) Erikss. and Henn., rust.

Puccinia graminis Pers., stem rust; common in Uganda.

Puccinia triticina Erikss.

Ustilago tritici (Pers.) Jens., smut.

UROCHLOA sp.

Uromyces leptodermus Syd., rust.

ZEA MAYS (Maize).

Sclerospora graminicola (Sacc.) Schrot.; this record is doubtful, as the species found in Uganda does not exactly correspond to this species; cases of downy mildew on maize are rare here.

Ophiobolus sativus (P. K. & B.) Ito and Kurib., conidial stage *Helminthosporium sorokinianum* Sacc., leaf spot and foot rot.

Gibberella saubinetii (Mont.) Sacc., conidial stage *Fusarium graminearum* Schwabe, foot rot and grain disease; affected ears show a pink to purplish discoloration of the seed, limited to a few seed or involving a large part of the ear.

Gibberella fujikuroi (Saw.) Wr., var. *subglutinans* Edw., conidial stage *Fusarium moniliforme* var. *subglutinans* Wr., causing symptoms similar to the foregoing.

Puccinia maydis Bereng. (*P. sorghi* Schw.), rust.

Nigrospora oryzae (B. & Br.) Petch., on leaves.

Nigrospora sphaerica Sacc., on leaves.

Helminthosporium turcicum Pass., leaf disease, similar to that caused by the same fungus on Sorghum.

Fusarium semitectum B. & Rav., common on dying tissues.

Rhizoctonia bataticola (Taub.) Butl., uncommon on this host.

Cercospora sorghi E. & Ev., leaf spot.

Colletotrichum graminicolum (Ces.) Wils., leaf spot.

Mosaic Disease, though common on sugar cane, has not been recorded on Maize in Uganda.

Streak Disease, universal in Uganda; the leaves show yellow to white streaks, and plants badly affected are sterile or yield little, being often much dwarfed.

FUNGI PARASITIC ON ANIMALS.

NEMATODES.

Myzocytium vermicolum (Zopf) Fischer, on *Anguillula* sp.

INSECTS.

Empusa gryllii, on locusts.

E. aphidis, on aphis on cotton, etc.

E. muscae, on house flies.

Entomophthora sphaerosperma, on flies, *Dysdercus*, etc.

Penicillium brevicaule Sacc., on *Dysdercus*.

Myrangium duriaei Mont. & Berk., on various scales.

Nectria tuberculariae Petch, on citrus scales.

Cordyceps lloydii Fawcett, on an ant.

Cordyceps nutans Pat., on a Pentatomid bug.

Cordyceps dipterigena, on flies.

Cordyceps bicephala, on ants.

Hypocrella raciborskii Zimm., on scales.

Hypocrella javanica (P. & S.) Petch. on citrus scales.

Podonectria coccicola (E. & E.) Petch, on citrus scales.

Aschersonia coffeae P. Henn., on scales.

Aschersonia placenta B. & Br., on scales.

Aschersonia crenulata Pat. & Har., on scales.

Aschersonia zenkeri P. Henn., on scales.

Cephalosporium lecanii Zimm., on scales.

Beauveria bassiana (Bals) Vuill., on *Stephanoderes*.

Hirsutella floccosa Speare.

Hirsutella sp. (nov.?), on *Habrochila*.

Torula sp.

Spicaria sp.

Isaria sphingum.